

PROJECT SUMMARIES

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT

R. W. Adler, Research Associate Professor

W.R. Vincent, Visiting Research Associate

Department of Electrical and Computer Engineering

Sponsor: Naval Security Group Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Navy receiving sites and Regional SIGINT Operational Sites (RSOCs) worldwide.

SUMMARY: Development continued of techniques and methodology for identifying and locating radio noise sources and sources of interference to data processing and computer systems at the Naval Security Group (NSG) sites worldwide. Support was provided to NSG via review of pre-survey planning documentation, mitigation plans, and authoring “Quick-Look” and final site-survey reports. Students and NSG site personnel were trained as part of the NSG support. A two-day HF Technical Review of Factors that Affect Performance of Naval Receiving Sites was organized and held in Washington, DC, in May 1997.

PUBLICATIONS:

Vincent, W.R. and Adler, R.W., “SNEP Team Quick-Look Report, NSGD, Rota, Spain, CDAA Site,” COMMNAVSECGRU N-44, January 1997.

Vincent, W.R. and Adler, R.W., “Signal-to-Noise Enhancement Program Survey, Quick Look Report,” NSGA Northwest,” COMMNAVSECGRU N-44, June 1997.

Vincent, W.R. and Adler, R.W., “Signal-to-Noise Enhancement Program Survey, Technical Report, NSGA Northwest,” COMMNAVSECGRU N-44, July 1997.

Vincent, W.R. and Adler, R.W., “SNEP Team Quick-Look Report, NSGD, Rota, Spain, CDAA Site,” COMMNAVSECGRU N-44, July 1997.

Vincent, W.R. and Adler, R.W., “SNEP Team Signal Reception Survey, NSGA Guantanamo Bay, Cuba,” COMMNAVSECGRU N-44, September 1997.

Vincent, W.R., Munsch, G.G., Perry, R.M., and Parker, A.A., “EMI Susceptibility of Communication Cables,” Technical Memorandum CABLES9710, USAINSCOM, October 1997.

Vincent, W.R., Adler, R.W., and Myers, H.J., “EMI Leakage into the Radio Frequency Distribution System of a Receiving Site,” COMMNAVSECGRU N-44, Naval Postgraduate School Technical Report, NPS-EC-97-006, September 1997.

Vincent, W.R. and Munsch, G.G., “Power-Line Noise Mitigation Handbook, 4th Ed.,” COMMNAVSECGRU N-44, Ft. Meade, MD, April 1997.

CONFERENCE PRESENTATIONS:

Adler, R.W., “Myths of Zero and Equi-Potential Grounds,” Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

Adler, R.W., “Motor Controller EMI Mitigation,” Workshop on Factors Affecting the Performance of Naval Receiving Sites,” Ft. Meade, MD, May 1997.

Adler, R.W., “Fusion Light Testing,” Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

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Vincent, W.R., "EMI Coupling into the RFD of a CDAA," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

Vincent, W.R., "Performance Evaluation Technique," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

Vincent, W.R., "High Dynamic Range Amplifiers," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

Vincent, W.R., "Equipment Installation Practices," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Environmental Quality

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

ENHANCEMENTS FOR THE RADIO FREQUENCY MISSION PLANNER (RFMP)

R. W. Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Information Warfare Activity

OBJECTIVE: The goal of this ninth year of a continuing project was to conduct numerical analysis and experimental research in support of the Navy's requirement to site VLF through UHF communication antenna systems and support equipment in non-ideal locations. The effort this year was to support the propagation prediction models of the Radio Frequency Mission Planner (RFMP). In particular, the RFMP provides the warfighter an estimate of the probability of successfully receiving radio signals from 20 to 1500 MHz. The propagation models used in RFMP are tropospheric models that have not been validated in the littoral environment that the Navy is committed to. Data collection of real-world signals is required for the validation process. NPS was tasked to provide the sites and a radio noise-quiet instrumentation van and to conduct automated measurements of received signals in a littoral environment.

SUMMARY: The efforts involved the preparation of a radio noise quiet instrumentation van and the installation of an automated RF signal collection system in the van. A companion 6-band automated VHF-UHF transmitter system was also installed onboard the U.S. Coast Guard Cutter for two measurement campaigns and onboard the NPS research ship *Point Sur*. Data was collected along the coastal plain and coastal mountain range system from Santa Cruz to below Big Sur, as well as several inland valleys in San Benito, Santa Clara, Santa Cruz, and Monterey counties. Data reduction and summary reports are in preparation.

DoD KEY TECHNOLOGY AREAS: Sensors, Environmental Quality

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas, Radiowave Propagation

SYSTEM MODELING AND ANALYSIS CENTER SUPPORT FOR ANTENNA PERFORMANCE EVALUATION

R. W. Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Information Warfare Activity

OBJECTIVE: The System Modeling and Analysis Center (SMAC) is tasked to provide personnel and modeling tools to support all tri-service communication systems performance predictions for the warfighter. NPS is supporting this require-

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ment by providing user-friendly numerical modeling tools. The first deliverable in 1997, was a Windows graphical I/O interface for the NEC2-MOM antenna code. The completion of the task will include an upgrade of the NEC-2 code (NEC-Win PRO) called GNEC4, based on a customized version of the current NEC-4 code.

DoD KEY TECHNOLOGY AREAS: Sensors, Environmental Quality

KEYWORDS: Electromagnetic Environmental Effects, Antennas

FIELD STATION RESEARCH AND SUPPORT

R. W. Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Army Information Security Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Army Regional SIGINT Operational Sites and receiving sites worldwide.

SUMMARY: An electromagnetic interference (EMI) survey was conducted at Ft. Gordon, GA. The performance of receiving signals-of-interest evaluated and the EMI sources observed were documented.

PUBLICATION:

Vincent, W.R. and Adler, R.W., "EMI Survey at RSOC, Ft. Gordon, GA," USA INSCOM Technical Report, January 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Environmental Quality

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

CONTROLLER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS

Robert W. Ashton, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Annapolis Detachment and Naval Postgraduate School

OBJECTIVE: Four 100kW buck choppers are currently part of small-scale dc zonal electric distribution system at the Naval Surface Warfare Center (NSWC). The object of this research is to replace the existing first generation buck chopper analog/digital controllers with in-house designed digital signal processing controllers. These new controllers are to be built, programmed, and tested on prototype converters at the Naval Postgraduate School prior to delivery.

SUMMARY: During FY97 the programmable universal controller (PUC) was developed and implemented as specified in the "objective" above. The PUC, designed by NSWC personnel, was adopted by this investigator as the second-generation controller. The PUC is TMS320 based with ten available 200kHz A/D converters for acquiring sensor information. The PUC uses a computer for interfacing, and many PUCs may be daisy-chained via fiber optic cable. Electrical isolation is accomplished by the use of fiber optic cable to the power section transistor driver board, the computer interface board, and all follow-on PUCs. Each PUC can control two converters simultaneously. This required the building of three PUCs, two for NSWC and one for the NPS testbed. Documentation of the PUC had to be generated, since little was available from NSWC due to personnel changes.

Two prototype 9kW buck choppers that interface with the PUC were designed, built, and tested. These converters are closely matched so that future paralleling requirements could be implemented. After a PUC was built and tested, assembler code for the TMS320 was developed to run the choppers. The original multi-loop algorithm used in the first generation

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controller was coded and burned into the EPROMs. The NPS testbed which includes one PC, one PUC and two 9kW buck choppers was completed. After debugging, the converters were successfully operated at their full-power ratings.

At this point an interface card for the 100kW units at NSWC was designed, cut, populated, and tested at NPS. This card is required for local control, several protection features and the special Power Paragon IGBT driver boards. All necessary components for the new controllers were shipped to Annapolis for integration with the power sections. Currently, the converters are in operation with the new controllers.

This project is expected to continue as additional hardware is added to the distribution system. In the future, a new algorithm for paralleling the units without droop will need to be developed.

CONFERENCE PRESENTATIONS:

Ashton, R.W. and Ciezki, J.G., "The Formulation and Implementation of an Analog/Digital Control System for a 100kW DC-to-DC Buck Chopper," to be presented at the International Symposium on Circuits and Systems (ISCAS 98), Monterey, CA, June 1998.

Ashton, R.W., Ciezki, J.G., and Badorf, M.G., "The Synthesis and Hardware Validation of DC-to-DC Converter Feedback Controls," to be presented at the Power Electronics Specialists Conference (PESC 98), Tokyo, Japan, June 1998.

Ciezki, J.G. and Ashton, R.W., "The Design of Stabilizing Controls for Shipboard DC-to-DC Buck Choppers Using Feed-back Linearization Techniques," to be presented at the Power Electronics Specialists Conference (PESC 98), Tokyo, Japan, June 1998.

THESES DIRECTED:

Allen, Kirk D., "Practical Implementation of a DC-to-DC Buck Chopper in a Shipboard DC Power Distribution Network," Master's Thesis, Naval Postgraduate School, March 1997.

Badorf, Michael G., "Power Electronic Building Block Testbed Stability Criteria and Hardware Validation Studies," Master's Thesis, Naval Postgraduate School, June 1997.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Energy Conversion)

KEYWORDS: Power Electronic Building Blocks, Power System, DC Distribution, Zonal Architecture, Stability, Simulator

THE DEVELOPMENT OF AUXILIARY RESONANT COMMUTATED POLE (ARCP) BOOST RECTIFIER CONTROLS, AND THE CONSTRUCTION AND VALIDATION OF A SOFT-SWITCHED DC-TO-DC CONVERTER

Robert W. Ashton, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Annapolis Detachment

OBJECTIVE: The objective is to deliver an ARCP Boost Rectifier Control algorithm suitable for implementation into the Power Electronic Building Block (PEBB) Universal Control Law Library. Additionally, a soft-switching high-frequency buck converter that is suitable for integration into the PEBB Network Simulation Testbed.

SUMMARY: The ARCP Boost rectifier is a core element of the full-scale Power Electronic Building Block (PEBB) demonstration system while the soft-switched DC-to-DC converter is an efficient alternative to a conventional hard-switched topology. The investigator proposes to analyze and design through simulation the appropriate controls for an ARCP boost rectifier. In addition, it is proposed to design and construct a soft-switching high-frequency DC-to-DC converter for application in the PEBB network simulation testbed. Following a review of the device topology and desired operating character-

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istics, an appropriate simulation will be implemented and validated against existing hardware. The investigator will then use the simulation to develop suitable controls to ensure that boost operation is achieved and circulating currents are controlled or eliminated. The resultant control algorithm will be made available in a form that will be serial transferable to the PEBB Universal Controller. A hardware demonstration of the proposed control law will be implemented utilizing the fourth ARCP inverter, provided by Pennsylvania State University, and a PEBB Universal Controller - rev 0.

During FY97, extensive models were coded in ACSL. The results were inconclusive. The investigator is still working with the sponsor to further evaluate the system.

The soft-switched DC-to-DC converter proposed work includes a comprehensive literature search of efficient soft-switched resonant converter topologies. The investigator will simulate the attractive topologies and develop appropriate closed-loop controls. One of the topologies will then be selected for prototyping. A prototype of the chosen topology will be implemented at power/frequency levels available in the NPS power systems laboratory. A set of validation studies will be conducted to assess the performance of the unit subjected to both source and load transients. The hardware will then be interconnected into the PEBB Network Simulator to serve as a third DC source deriving power from the phase-controlled rectifier. As the network simulator design can only accommodate two source DC-to-DC converters, the additional converter must be wired with a manual "knife" switch as a hard "OR" selection.

During FY97 a number of resonant converters were investigated. Further, all the materials were purchased for the construction of any one of the investigated designs. The sponsor has not indicated the topology choice at this time.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Energy Conversion)

KEYWORDS: Power Electronic Building Blocks, Power System, DC Distribution, Zonal Architecture, Stability, Simulator

MULTIPLE-VALUED COMPUTER LOGIC CIRCUITS

Jon T. Butler, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: To analyze the irredundant sum-of-products approach to the design of digital circuits for determining efficient and compact computer designs.

SUMMARY: A commonly used approach to the design of digital logic circuits is to produce a sum-of-products expression for a given target function. Such circuits have the property that delay time is low and thus, computation speed is high. Ideally, one wants a sum-of-products expression with as few products as possible, since this produces a compact circuit. However, a class of functions has been discovered for which a recently proposed reduction algorithm produces the worst possible sum-of-products expression. This is quite unsuspected, and suggests that more is needed to understand how poorly such an algorithm can do. The goal of this project is to understand the fundamental properties of sum-of-products circuit design.

PUBLICATIONS:

Butler, J.T. and Sasao, T., "On the Properties of Multiple-Valued Functions that are Symmetric in Both Variable Values and Labels," Naval Postgraduate School Technical Report, NPS-EC-97-015, May 1998.

Butler, J.T. and Sasao, T., "On the Properties of Multiple-Valued Functions that are Symmetric in Both Variable Values and Labels," *Proceedings of the 28th International Symposium on Multiple-Valued Logic*, May 1998 (accepted).

Sasao, T. and Butler, J.T., "Comparison of the Worst and Best Sum-of-Products Expressions for Multiple-Valued Functions," *Proceedings of the 27th International Symposium on Multiple-Valued Logic*, pp. 55-60, May 1997.

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CONFERENCE PRESENTATION:

Sasao, T. and Butler, J.T., "Comparison of the Worst and Best Sum-of-Products Expressions for Multiple-Valued Functions," 27th International Symposium on Multiple-Valued Logic, May 1997.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Digital Systems, Compact Circuits, Computer-Aided Design Tools

REDUNDANT NUMBER SYSTEMS

Jon T. Butler, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: To analyze the use of redundant number systems in the realization of compact high-speed computation.

SUMMARY: In a redundant number system, at least one integer has at least two representations. While redundancy precludes the realization of the maximum number of integers, there are significant advantages. For example, "almost" carryless addition can be achieved, which implies fast computation time. Also, certain applications require representations with certain characteristics; e.g., no more than some upper limit on the number of adjacent 1's. This project is to analyze such number systems to fully realize their benefits.

PUBLICATIONS:

Butler, J.T. and Sasao, T., "On the Proportion of Digits in Redundant Numeration Systems," *The Fibonacci Quarterly*, pp. 172-180, May 1997.

Butler, J.T. and Sasao, T., "Redundant Multiple-Valued Number Systems," *Proceedings of the Japan Research Group on Multiple-Valued Logic*, Vol. 20, pp. 141-148, July 1997.

CONFERENCE PRESENTATION:

Butler, J.T. and Sasao, T., "Redundant Multiple-Valued Number Systems," *The Japan Research Group on Multiple-Valued Logic*, July 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Number Systems, High-Speed Numeric Computation

POWER ELECTRONIC BUILDING BLOCK (PEBB) NETWORK SIMULATION TESTBED VALIDATION AND THE DEVELOPMENT OF A PEBB UNIVERSAL CONTROL LIBRARY

John G. Ciezki, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: The proposed work is a continuation of the on-going research effort into the development of a PEBB network simulation testbed. The testbed facilitates the analysis and assimilation of test data concerning the stability of networks containing PEBB-like devices, the interaction of PEBB-like devices and high bandwidth controllers, the investigation of alternative control strategies for PEBB-like devices, and the dynamic performance of devices subjected to system

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transients. The simulator has been designed to offer flexibility in system reconfiguration, convenient monitoring, and an expandable architecture to readily integrate new or additional devices.

SUMMARY: The investigator completed the development of the simulation testbed and performed preliminary validation studies on various topologies. In addition, a library was developed of control laws for both the DC-to-DC converter and the Auxiliary Resonant Commutated Pole (ARCP) inverter. The simulation testbed work consisted of integrating the final ARCP inverters into the 19 inch rack, verification of the switch lock-out strategy, finalizing the DSP control of each power converter, the validation of a power-up and power-down procedure, the development and implementation of single device start-up, load and load-transient studies, the development and implementation of multiple device start-up, load and load-transient studies, and the modification of cabinet layout to account for any problems with cooling and electro-magnetic interference (EMI).

The Control Law Library work consisted of formulating via simulation appropriate control algorithms for application to both the DC-to-DC converter and the ARCP inverter. The algorithms will, in the future, be converted into C or C++ code that will be serially transferable to the DSP boards (PEBB Universal Controller). A variety of algorithms are available for the ARCP inverter including: space vector (via table lookup), sine-triangle pulse-width modulation, bang-bang pulse-width modulation, battery charger mode, induction machine start-up, and paralleling. Several algorithms are readied for the DC-to-DC converter including: modified state feedback, state feedback with on-line estimator, local extract linearization control, and one-cycle feed-forward control.

CONFERENCE PRESENTATIONS:

Ciezki, J.G. and Ashton, R.W., "The Resolution of Algebraic Loops in the Simulation of Finite-Inertia Power Systems," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

Ciezki, J.G. and Ashton, R.W., "The Design of Stabilizing Controls for Shipboard DC-to-DC Buck Choppers Using Feedback Linearization Techniques," to be presented at the Power Electronics Specialists Conference (PESC '98), Tokyo, Japan, June 1998.

Ciezki, J.G. and Ashton, R.W., "The Application of Feedback Linearization Techniques to the Stabilization of DC-to-DC Converters with Constant Power Loads," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Computing and Software

KEYWORDS: Power Electronic Building Block, Power Converters, Controls, Paralleling Algorithm

INTERACTIONS AND DYNAMICS OF POWER ELECTRONIC BUILDING BLOCK NETWORK CONTROLLERS

John G. Ciezki, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Carderock Division and Naval Postgraduate School

OBJECTIVE: The purpose of this research endeavor was to investigate the interaction dynamics of digitally controlled DC-to-DC power converters and Auxiliary Resonant Commutated Pole (ARCP) inverters interconnected in a variety of topologies. In particular, the Navy was interested in quantifying the interaction phenomenon that may occur when several high bandwidth converters are connected as anticipated in the DC Zonal Electrical Distribution System proposed for the twenty-first century surface combatant.

SUMMARY: The project consisted of properly developing the controls for the DC-to-DC converters and the ARCP inverters, integrating the units in a variety of series and parallel connections, performing validation studies consisting of variations in loading and transients in the input voltages, and deriving stability conclusions using both validated computer

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simulation models and the hardware test results. Interesting tradeoffs were uncovered in terms of designing the control loop for the DC-to-DC converters and optimizing the selection of output capacitance for the units. The paralleling scheme for the DC-to-DC converters utilized the standard droop approach. Future endeavors will investigate the feedback of output current to implement the current share.

CONFERENCE PRESENTATIONS:

Ashton, R.W. and Ciezki, J.G., "The Design and Fabrication of a Reconfigurable Hardware Testbed for Interaction Analysis of Power Converters in a Reduced-Scale Navy DC Distribution System," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

Ashton, R.W. and Ciezki, J.G., "The Formulation and Implementation of an Analog/Digital Control System for a 100kW DC-to-DC Buck Chopper," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

Ashton, R.W., Ciezki, J.G., and Badorf, M.G., "The Synthesis and Hardware Validation of DC-to-DC Converter Feedback Controls," to be presented at the International Symposium on Circuits and Systems (PESC '98), Tokyo, Japan, June 1998.

Ashton, R.W. and Ciezki, J.G., "The Analysis of Tradeoffs Between Power Section Hardware and Feedback Gains for a DC Distribution System DC-to-DC Converter," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Computing and Software

KEYWORDS: Power Electronic Building Block, High Bandwidth Controllers, Power Electronic Converters

SIGNAL DENOISING USING WAVELET THRESHOLDING TECHNIQUES

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Undersea Warfare Center-Newport Detachment and Naval Postgraduate School

OBJECTIVE: The goal of the study is to investigate the application of the wavelet transform to denoising purposes. The proposed study is divided in two parts. The first part focuses on the type of decomposition and wavelet basis to be used, while the second part investigates specific wavelet thresholding techniques. The study focuses on data provided by the sponsor and results are compared to those obtained using classical Wiener filtering.

SUMMARY: This study investigated the application of the wavelet transform and wavelet and cosine packets signal decompositions for the removal of noise from underwater acoustic signals. Several wavelet-based denoising techniques were presented and their performances compared. Results from the comparisons were used to develop a wavelet-based denoising algorithm suitable for a wide variety of signals. Performances of the denoising algorithm were compared to those of a short-time Wiener filter implementation and demonstrated that wavelet-based methods are a viable tool for the denoising of acoustic data.

PUBLICATIONS:

Fargues, M.P. and Barsanti, R.J., "Wavelet-Based Denoising: Comparisons between Orthogonal and Non-Orthogonal Decompositions," *Proceedings of the 40th Midwest Symposium on Circuits and Systems*, August 1997.

Fargues, M.P., Barsanti, R.J., and Hippenstiel, R., "Wavelet-Based Denoising of Transients," Naval Postgraduate School Technical Report, NPS-EC-97-005, February 1997.

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CONFERENCE PRESENTATION:

Fargues, M.P. and Barsanti, R.J., "Wavelet-Based Denoising: Comparisons between Orthogonal and Non-Orthogonal Decompositions," 40th Midwest Symposium on Circuits and Systems, Sacramento, CA, August 1997.

OTHER:

Fargues, M.P., "Signal Classification Issues Using Wavelet Decompositions," seminar given at NUWC - Newport, RI, August 1997.

Fargues, M.P., "Signal Denoising and Classification," one-hour briefing presented at NAVSEA, Crystal City, VA, August 1997.

THESIS DIRECTED:

Bennet, R., Jr., "Classification of Underwater Signals Using a Back-Propagation Neural Network," Master's Thesis, Naval Postgraduate School, June 1997.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software

KEYWORDS: Signal Classification, Wavelet Transform

ECONOMIC EVALUATION OF VOICE RECOGNITION FOR THE CLINICIAN'S DESKTOP AT THE NAVAL HOSPITAL ROOSEVELT ROADS (NHRR)

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Student Sponsors: Naval Medical Information Management Center and
Defense Health Resources Study Center

OBJECTIVE: To investigate the status of voice recognition (VR) technology and provide an analysis of the voice recognition pilot project at the Naval Hospital Roosevelt Roads (NHRR). To determine the viability and economic benefits of using a Commercial-Off-The-Shelf (COTS) VR application as a clinician input device for transcribing to clinical encounter (SOAP) notes.

SUMMARY: This study investigated the application of voice recognition technology as an input device for electronic medical record (EMR) at NHRR. EMR templates designed to be integrated with the voice recognition software were used for the testing phase. Surveys were designed and distributed both at Navy medical conferences, and at NHRR to evaluate the perception and viability of the pilot project. Findings indicated that the backbone for a successful integration of the technology into the healthcare environment is a strong information system support. In addition, findings showed the following primary healthcare advantages: (1) increased productivity with comparable or better accuracy than can be achieved using existing input methods without negative impact on patient satisfaction and (2) reduction in the need for transcriptionists to transcribe data which can add numerous economical benefits to military healthcare organizations. The primary disadvantages in healthcare are: (1) possible interference from noise, distortion or variability in the user's speech pattern; (2) concerns regarding a patient's privacy violation; and (3) finally, limitations in VR software capabilities.

PUBLICATION:

Fargues, M.P. and Threet, E., "Economic Evaluation of Voice Recognition for the Clinician's Desktop at the Naval Hospital Roosevelt Roads (NHRR), *Journal of Military Medicine* (submitted November 1997).

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THESIS DIRECTED:

Threet, E., "Economic Evaluation of Voice Recognition for the Clinician's Desktop at the Naval Hospital Roosevelt Roads (NHRR)," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software

KEYWORDS: COTS, Voice Recognition, EMR

RADIATION TOLERANT BULK CMOS DIGITAL INTEGRATED CIRCUITS

Douglas J. Fouts, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: National Security Agency and Naval Postgraduate School

OBJECTIVE: To develop circuit designs and mask layout techniques that improve the radiation tolerance of digital integrated circuits fabricated with standard, commercial, bulk CMOS processes.

SUMMARY: This research project is investigating circuit designs and mask layout techniques that can be used with standard, commercial, bulk CMOS processes to make digital integrated circuits (ICs) fabricated with these processes tolerant of natural space radiation. Work is concentrating on two areas. First, reducing subthreshold, gate end-around leakage current which is caused by the buildup of radiation-induced charge in the field oxide along the edge of the conducting channel of the transistor. Second, compensating for shifts in threshold voltage that are caused by the buildup of radiation-induced charge in the gate oxide. The first goal of the research has recently been accomplished and work is now proceeding with the second goal. The results of this research will greatly reduce the cost of radiation-tolerant digital integrated circuits for space applications.

THESES DIRECTED:

Lambley, A.S., "Evaluation of Layout Techniques for Radiation Tolerant Bulk CMOS Integrated Circuits," Master's Thesis, Naval Postgraduate School, September 1997.

Noe, S.S., "Alternative Gate Designs for Improved Radiation Hardness in Bulk CMOS Integrated Circuits," Master's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

KEYWORDS: Radiation-Hardened Electronics, Space Electronics

DYNAMIC LOGIC CIRCUITS FOR COMPLEMENTARY GALLIUM FABRICATION PROCESSES

Douglas J. Fouts, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: To investigate the speed, power consumption, and noise sensitivity of dynamic logic circuits implemented with complementary gallium arsenide fabrication processes.

SUMMARY: Logic circuits implemented with gallium arsenide (GaAs) metal field effect transistors (MESFETs) can consume fairly large amounts of power when operated at high frequencies. An alternative is to implement the logic with

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complementary hetero isolated gate field effect transistors (CHIGFETs). This yields logic circuits with reduced power consumption but also reduced speed. However, by using the new dynamic logic circuits that have been developed by this research project, in conjunction with a CHIGFET fabrication process, the high speed of GaAs MESFET logic can be maintained while at the same time reducing the power consumption to a level that is below the power consumption for the static logic circuits that are more typically used with CHIGFET fabrications processes.

PUBLICATIONS:

Fouts, D.J., Shehata, K.A., and Michael, S., "Dynamic Logic Families for Complementary Gallium Arsenide (CGaAs) Fabrication Processes," *Proceedings of the 40th IEEE Midwest Symposium on Circuits and Systems*, CD-ROM, Sacramento, CA, 3-6 August 1997.

Shehata, K.A., Fouts, D.J., and Michael, S., "A Dynamic Four-Bit Carry Look-Ahead Adder Circuit for Complementary Gallium Arsenide (CGaAs) Fabrication Processes," *Proceedings of the 40th IEEE Midwest Symposium on Circuits and Systems*, CD-ROM, Sacramento, CA, 3-6 August 1997.

CONFERENCE PRESENTATIONS:

Fouts, D.J., Shehata, K.A., and Michael, S., "Dynamic Logic Families for Complementary Gallium Arsenide (CGaAs) Fabrication Processes," 40th IEEE Midwest Symposium on Circuits and Systems, Sacramento, CA, 3-6 August 1997.

Shehata, K.A., Fouts, D.J., and Michael, S., "Dynamic Four-Bit Carry Look-Ahead Adder Circuit for Complementary Gallium Arsenide (CGaAs) Fabrication Processes," 40th IEEE Midwest Symposium on Circuits and Systems, Sacramento, CA, 3-6 August 1997.

PATENT APPLICATION:

Fouts, D.J. and Shehata, K.A., "Two-Phase Dynamic Logic Circuits for Gallium Arsenide Complementary HIGFET Fabrication Processes," November 1997.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

KEYWORDS: Dynamic Logic, Gallium Arsenide Logic, Dynamic Gallium Arsenide Logic, High-Speed Low-Power Logic

READ PREDICTION CACHE MEMORIES FOR EMBEDDED MICROPROCESSOR SYSTEMS

Douglas J. Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To develop an alternative to second-level cache memories for spacecraft, weapon systems, network controllers, and other embedded high-performance, low-power, microprocessor applications.

SUMMARY: Second-level cache memories for high-performance microprocessor systems require large arrays of high-speed, static random access memory (SRAM), which greatly increases the power consumption, weight, physical size, and cooling requirements of the microprocessor integrated circuit (IC) and system. By using address prediction techniques, a significantly smaller cache can provide the same performance with significantly reduced power consumption, weight, physical size, and cooling requirements. Single-chip VLSI implementations of read prediction caches are possible, which can reduce design time and improve system reliability. Inclusion of a read prediction cache memory on the actual CPU chip

PROJECT SUMMARIES

is also possible because of the reduced amount of logic required for implementation, compared to a standard second-level cache memory.

PUBLICATION:

Fouts, D.J., Nowicki, G.J., and Aguilar, M.E., "A CMOS Read Prediction Buffer IC for Embedded Microprocessor Systems," *Journal of Microelectronic System Integration*, Vol. 5, No. 3, pp. 129-138, September 1997.

PATENT APPLICATION:

Fouts, D.J., "Predictive Read Cache Memories for Reducing Primary Cache Miss Latency in Embedded Microprocessor Systems," November 1997.

OTHER:

A high-performance, general-purpose, computer architecture simulation program has been written for performing address-trace driven simulations of instruction execution, address patterns, and cache memory and main memory behavior.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

KEYWORDS: Embedded Computing, Portable Computing, High-Speed Networking, High-Performance Microprocessors

MILITARIZATION OF COMMERCIAL LOW EARTH ORBIT SATELLITE SYSTEMS (LEOS)

Tri T. Ha, Professor

Vicente Garcia, National Security Agency Cryptologic Chair

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School

OBJECTIVE: To investigate the use of four commercial low earth orbit satellite systems (LEOS) for disseminating operational intelligence to allies-coalition forces and providing voice and data capability for military applications.

SUMMARY: An in-depth study was provided for each of the following four commercial LEOS: Iridium, Teledesic, Odyssey, and Globalstar. Then, a comparison of these systems was performed from the military point of view by using criteria such as anti-jam protection, security, mobility, flexibility, interoperability, coverage, and capacity. It was shown that an architecture consisting of Globalstar and Odyssey had the potential to provide communications support for DoD's less critical needs, which include administration, logistics, and other support functions. Finally, other military applications of these systems were given.

THESIS DIRECTED:

Kakavas, I., "The Applications in Military Communications of Low and Medium Earth Orbit Commercial Satellite Systems," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Other (Communication Networking)

KEYWORDS: LEOS, Iridium, Teledesic, Globalstar, Odyssey, ICO

PROJECT SUMMARIES

PROCESSING OF SECOND ORDER STATISTICS VIA WAVELET TRANSFORMS

Ralph D. Hippenstiel, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: To develop and investigate the properties of a wavelet based approach in detecting and classifying digital modulated signals. A wavelet transform, replacing the traditional Fourier transform in the computation of the time-frequency distribution, is used to obtain a scale-time/delay distribution. Also transformation will be addressed.

SUMMARY: This work addresses modulation identification and parameter extraction of digital communication signals. Wavelets are applied to the two-dimensional instantaneous correlation function to extract transition points and to allow modulation identification. Additional parameters are extracted using the transition points obtained in the wavelet processing. Wavelets can be applied along the time or the delay axis. A performance curve versus signal-to-noise ratio (SNR) is provided.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Wavelets, Time Frequency Distributions, Signal Detection/Classification

MISSILE CLOSURE SIMULATION AND ANALYSIS TO SUPPORT TESTING MISSILE APPROACH WARNING SYSTEMS

Robert G. Hutchins, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Warfare Center-Weapons Division

OBJECTIVE: The Naval Air Warfare Center-Weapons Division (NAWCWD) is undertaking a study of simulation methodologies to support testing missile approach warning systems (MAWS). They have two programs of interest in this area, the Missile on the Mountain-Ground Mounted Seeker (MOM-GMS) radar enhancement project at the Electronic Combat Range, China Lake, CA, and the Joint Electronic Combat test using SIMulation (JECSIM) Joint Test and Evaluation (JT&E) program. The Naval Postgraduate School (NPS) has been tasked to assist in this effort along two paths: first by acting as the focal point for missile fly-out simulations and studies, and second to assist in the radio frequency (RF) portion of the MAWS study by developing and implementing real-time algorithms to assist a ground-mounted, stationary RF seeker to perceive a more realistic view of incoming targets through the use of simulation enhancements. Comparison of missile fly-out simulations with actual live-fire test data was the dominant research area for FY97.

SUMMARY: NAWCWD is involved in a large tri-service effort to develop testing procedures for assessing aircraft response mechanisms to threat surface-to-air missile (SAM) systems. To this end, realistic sensors, sensor simulators, missile fly-out geometries, and end-game intercept geometries for a wide range of sensor types and missile types must be assessed. This research has allowed the Department of Electrical and Computer Engineering to obtain the enhanced surface-to-air missile simulation (ESAMS) code from the Survivability/Vulnerability Information Analysis Center (SURVIAC) at Wright-Patterson Air Force Base. It has been hosted and tested on an SGI Indigo2 computer in the classified computer facility in Root Hall (this code is classified at the SECRET level). Prior work has centered on simulation studies using ESAMS to validate missile end-game behavior for specific threat systems. This past year's research has focused on two areas: an analysis of missile miss distance due to target maneuver and decoy deployment, and the comparison of actual missile flight test data with ESAMS simulated data using the same initial conditions. These results were briefed to the sponsor and others in a classified briefing presented at the Joint Electronic Combat test using SIMulation (JECSIM) Joint Test and Evaluation (JT&E) program review held at NPS, 23 October 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare, Modeling and Simulation

KEYWORDS: Sensors, Integration, Missile Guidance, Real-Time Simulation

PROJECT SUMMARIES

EVALUATIONS AND EXTENSIONS OF THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING ALGORITHM TO CLUTTERED ENVIRONMENTS

Robert G. Hutchins, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Undersea Warfare Center-Newport Detachment

OBJECTIVE: Dr. Roy Streit and colleagues at the Naval Undersea Warfare Center, Division Newport, have developed a probabilistic multi-hypothesis tracking (PMHT) algorithm that simplifies multi-hypothesis tracking and thus extends the applicability of these techniques to a broader range of problems. Analysis and testing to date have not included three key areas: a comparison with a traditional MHT algorithm, the study of cluttered environments, or the use of attribute data in measurement-to-track association. The purpose of the research effort at NPS is four-fold: (1) to test and validate this new algorithm by comparing it with a traditional MHT algorithm using standardized test scenarios; (2) to study comparative algorithm performance in the presence of clutter; (3) to enhance system performance by revising clutter initiation procedures; and (4) to initiate a study of attribute-augmented measurement-to-track association procedures for potential inclusion in a new algorithm at a later date. The ultimate goal is to develop a workable set of algorithms that is practical and that will achieve reasonable performance in the presence of clutter.

SUMMARY: Prior work in this project has produced a set of simulation testbeds and algorithm code. This past year, research has centered on comparison studies with other algorithms and on the use of attribute information to enhance tracking capabilities in clutter. Specifically, addressed was tracking in clutter with varying clutter densities, track initialization problems and procedures, measurement preprocessing, and the use of attribute data for clutter reduction.

PUBLICATIONS:

Hutchins, R.G. and Dunham, D.T., "Evaluations of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," *Proceedings of 30th Asilomar Signals Systems and Computers*, IEEE Paper, pp 1260-1264, 1997.

Dunham, D.T. and Hutchins, R.G., "Tracking Multi-Hypothesis Targets in Cluttered Environments with a Probabilistic Multi-Hypothesis Tracker," Acquisition Tracking and Pointing XI, M.K. Masden and L.A. Stockum (eds.), *Proceedings of SPIE*, Vol. 3086, pp. 284-295, 1997.

Hutchins, R.G. and Dunham, D.T., "Evaluations and Extensions of the Probabilistic Multi-Hypothesis Tracking Algorithm to Cluttered Environments, Naval Postgraduate School Technical Report, NPS-EC-97-009, December 1996.

CONFERENCE PRESENTATIONS:

Dunham, D.T. and Hutchins, R.G., "Tracking Multi-Hypothesis Targets in Cluttered Environments with a Probabilistic Multi-Hypothesis Tracker," SPIE Conference on Guidance and Navigation, Orlando, FL, April 1997.

Hutchins, R.G. and Dunham, D.T., "Evaluations of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," 30th Asilomar Signals Systems and Computers, Pacific Grove, CA, November 1996.

THESIS DIRECTED:

Dunham, D.T., "Tracking Multiple Targets in Cluttered Environments with the Probabilistic Multi-Hypothesis Tracking Filter," Master's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Sensors, Data Association, Target Tracking

PROJECT SUMMARIES

THEATER BALLISTIC MISSILE DEFENSE-MULTI-SENSOR FUSION, TRACKING, AND TARGETING TECHNIQUES

Robert G. Hutchins, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: The ultimate goal is to assess the feasibility of algorithms employing both strategic and theater sensors to detect, track, and engage theater ballistic missiles during boost and/or early ballistic missile flight, destroying the missile over the territory of the aggressor.

SUMMARY: The research this past year has focused on initialization and tracking of ballistic missiles during boost phase and through the transition between boost and ballistic flight. Various tracking algorithms have been studied. The effects of initialization on tracker performance to assess the feasibility of performing a hand-off between satellite and earth-based sensors are currently being examined.

PUBLICATION:

Hutchins, R.G. and San Jose, A.P., "IMM Tracking of a Theater Ballistic Missile during Boost Phase," Oliver Drumond, (ed.), *Proceedings of SPIE Signal and Data Processing of Small Targets*, Vol. 3373, pp. 528-537, 1998.

CONFERENCE PRESENTATION:

Hutchins, R.G. and San Jose, A.P., "IMM Tracking of a Theater Ballistic Missile during Boost Phase," SPIE Signal and Data Processing of Small Targets, Orlando, FL, April 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Theater Ballistic Missiles, Sensors, Extended Kalman Filters, Data Association, Target Tracking

PROPAGATION PREDICTION TECHNIQUES OVER ROUGH OCEAN AND UNEVEN TERRAIN

R. Janaswamy, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego and Naval Postgraduate School

SUMMARY: The problems of radiowaves propagating over rough ocean surface and in non-standard atmosphere and that of radiowaves propagating over uneven terrain and inhomogeneous atmosphere were solved by the parabolic equation method. Both horizontal and vertical polarizations were considered. FORTRAN codes were developed for both and delivered to sponsor.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Radiowave Propagation

PROJECT SUMMARIES

COMPUTER MODELING TECHNIQUES FOR ARRAY ANTENNAS ON COMPLEX STRUCTURES

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force and Naval Postgraduate School

OBJECTIVE: The objective of this research is to investigate the suitability of using several existing computational electromagnetics (CEM) codes in modeling antenna problems to predict the antenna's performance when it is in its operational environment, that is, when installed on a platform with other objects near it or in its field of view.

SUMMARY: Several off-the-shelf CEM codes have been used to model a wide range of antenna problems. They include simple dipoles and slots as well as microstrip patches and horns. These codes are well suited to the evaluation of antenna gain and pattern characteristics under various operational conditions. The purpose of this research was to demonstrate some of the features of the codes that are of use in the design and analysis of antennas on complex structures. The performance of individual elements and arrays of elements on complex structures has been computed using electromagnetic patch codes. Complex structures are defined as those with curved surfaces, edges, protrusions, and multiple materials.

Many of the codes are derivatives of RCS prediction codes, and have been thoroughly validated. Furthermore, pre- and post-processing tools have been developed to generate geometry models and visualize data. All of the codes examined in this study are available free to government agencies and contractors.

PUBLICATIONS:

Jenn, D.C. and Herzog, S., "Computed and Measured Radiation Patterns of Antennas with Aerodynamic Radomes," *Proceedings of the Applied Computational Electromagnetics Symposium*, March 1997.

Jenn, D.C., "Computer Modeling Techniques for Array Antennas on Complex Structures," Naval Postgraduate School Technical Report, NPS-EC-97-016, December 1997.

OTHER:

Jenn, D.C., "Computer Modeling Techniques for Array Antennas on Complex Structures," Progress Report, 1 July 1997.

THESIS DIRECTED:

Daniil, I.E., "Analysis of Finite Phased Arrays on Shaped Ground Planes," Master's Thesis, Naval Postgraduate School, December 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Array Antennas, Computational Electromagnetics

SURVEILLANCE SYSTEM STUDIES

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Sponsors: Space and Naval Warfare Systems Command and Naval Postgraduate School

OBJECTIVE: The objective of this project was to investigate the feasibility of using a computer simulation of a high frequency, shipboard direction finding system as a recalibration decision support system.

SUMMARY: Shipboard direction finding (DF) in the high frequency (HF) band is complicated by the fact that the antenna elements in the DF array interact strongly with the ship's superstructure. Thus, a DF technique such as correlation interfer-

PROJECT SUMMARIES

ometry direction finding (CIDF), which accounts for the effects of the superstructure must be used. However, CIDF requires a calibration database of DF antenna responses and any changes made to the superstructure after calibration may affect the accuracy of bearing estimates. This poses a problem, as one must know when a topside change will result in the need to recalibrate a ship—a costly and time consuming process.

A computer simulation was developed using operational system software. It was constructed to accept numerical, scale model, or real ship data, and to display correlation and bearing error results using 2D and 3D graphic displays. Numerical models of the DD963 Spruance Class destroyer were developed for two different topside configurations. The models were numerically calibrated and the bearing error caused by changing configuration was determined. Experimental data were used to validate the simulation.

Results were obtained at four frequencies through the HF band. Numerical and experimental DF antenna responses were in good agreement at the lower frequencies. At the higher frequencies, numerical and experimental DF antenna responses were not in good agreement. This was attributed to correctable deficiencies in the numerical ship models. Similarly, numerical and experimental correlation and bearing error results showed good agreement at low frequencies and poor agreement at high frequencies. However, numerical and experimental values of RMS bearing error, which is an integrated performance measure, showed good correspondence at all frequencies.

This work has shown that computer simulation could be used as a basis for developing a ship recalibration decision support system. Areas requiring further development to facilitate this approach include: (1) generation of ship numerical models from CAD files and (2) development of EM code pre/post processors for editing input data files, visualization of input data files, and viewing output data files. A comparison of the performance of available EM codes for this application would also be desirable. The simulation is immediately useful for analysis of real-ship data.

PUBLICATIONS:

Knorr, J.B., “Numerical and Experimental Responses for the OUTBOARD DF Antennas on the DD963 Spruance Class Destroyer,” Naval Postgraduate School Technical Report, NPS-EC-97-008, April 1997.

Knorr, J.B., “Application of Computational Electromagnetics to Shipboard HFDF System Simulation,” *Proceedings of the 13th Annual Review of Progress in Applied Computational Electromagnetics*, pp. 182-192, Monterey, CA, 17-21 March 1997.

Knorr, J.B., “Shipboard HFDF System Simulation,” *Applied Computational Electromagnetics Society Journal*, accepted for publication, March 1998.

CONFERENCE PRESENTATION:

Knorr, J.B., “Application of Computational Electromagnetics to Shipboard HFDF System Simulation,” 13th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, 17-21 March 1997.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Electronic Warfare, Modeling and Simulation, Sensors

KEYWORDS: Direction Finding, DF, HFDF, Modeling and Simulation, Computational Electromagnetics, CEM

DD963 ANTENNA DATA ANALYSIS

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: The objective of this project was to transfer NPS developed simulation technology for analysis of DD963 antenna data.

PROJECT SUMMARIES

SUMMARY: A computer simulation of the DD963 Spruance Class destroyer high frequency direction finding simulation was transferred to the RDT&E Division of SSC-SD. The various data processing, signal processing, and display software programs were provided along sample files and a User's Guide.

OTHER:

Knorr, J.B., "OUTBOARD DF System Simulation: User's Guide, Software, and Sample Files," prepared for Code D-8505, RDT&E Division, SSC-SD, San Diego, CA, 14 pp. plus software and sample files on disk.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Electronic Warfare, Modeling and Simulation, Sensors

KEYWORDS: Direction Finding, DF, HFDF, Modeling and Simulation, Computational Electromagnetics, CEM

LOW COST FINLINE FILTER CONSTRUCTION METHOD

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: The objective of this research was to investigate a low cost approach to the construction of finline bandpass filters for use at microwave and millimeter wave frequencies.

SUMMARY: In those applications where low insertion loss is required, waveguide is normally the best choice of medium for filter construction. Finline is an attractive choice for fabrication of the filter elements because printed circuit techniques can be used to produce the filter structure. Often the filter structure is fabricated using a thin piece of beryllium copper which has both stiffness and good conductivity. The printed filter structure is supported in the waveguide, in the E-plane, by bifurcating the waveguide and clamping the filter structure between the two halves of the waveguide. However, this approach to filter construction only partially addresses the issue of low cost since the waveguide halves must be machined.

A new approach to the construction of finline bandpass filters was investigated. Beryllium copper was used to fabricate a filter insert which was bent in a way which permitted it to be inserted directly into a standard waveguide. The response of this filter was measured and initially it was found that poor contact between the insert and the waveguide walls resulted in unacceptably high insertion loss. This problem was solved by using a conductive lubricant. The final result was an extremely simple, low cost filter construction method which resulted in an insertion loss which was only slightly greater than that of the conventional construction method.

PATENT:

Knorr, J.B., "Low Cost Finline Filter Construction Method," invention disclosure dated 22 December 1997.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Finline Filter

PROJECT SUMMARIES

EA6-B ANTENNA DESIGN AND EVALUATION SUPPORT

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Crane Division

OBJECTIVE: To cooperate with the contractor (AEL-Tracor) and Crane NSWC in predicting the performance of the proposed antennas for the EA6-B AN/ALQ-99 Low-Band Transmitter.

SUMMARY: AUTOCAD models of proposed antennas, the AN/ALQ-99 pod and the EA6-B aircraft were used as inputs to a Method of Moments program (named MOM-IV and developed at the NPS) to predict the radiation patterns and input impedances over a wide frequency range. The results were presented in the form of two reports, one for vertically polarized antennas and one for horizontally proposed antennas.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Antennas, Modeling and Simulation

ELECTROMAGNETIC CHARACTERIZATION OF METALLIC PLATFORMS VIA EIGEN-FUNCTION ANALYSIS

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To determine the “frequencies of opportunity” (resonances) of complex metallic objects and platforms such as missiles, land vehicles, aircraft, and ships, and the associated current distributions for the purposes of antenna coupling evaluation, improving detection of metallic targets (radar targets as well as unconventional targets such as concealed weapons), maximizing the effectiveness of electromagnetic attack, etc.

SUMMARY: Electromagnetic eigen-analysis program named EIGEN that had been developed at NPS by the PIs has been further improved with the NELO funding to predict more accurately the frequencies of electromagnetic resonances (and the associated current distributions and far field patterns) of complex metallic objects, based on the AUTOCAD wire-grid models as input. The work also involved the development of the Graphical User Interface (GUI) and will continue into 1998.

CONFERENCE PRESENTATION:

Lebaric, J., “Method of Moments Eigen-Analysis,” NATO Advanced Study Institute in Applied Computational Electromagnetics, August 1997.

THESIS DIRECTED:

Lintz, W., “Electromagnetic Resonances of Metallic Bodies,” Master’s Thesis, Naval Postgraduate School, June 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Modeling and Simulation, Electromagnetic Resonance, Eigen-Analysis

PROJECT SUMMARIES

TIME-DOMAIN SIMULATION OF RECEIVING SYSTEMS USING MATLAB/SIMULINK COMMUNICATIONS TOOLBOX

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: To develop a specialized “toolbox” to simulate the process of signal intercept in the time domain.

SUMMARY: A custom SIMULINK library has been developed with models of communications and radar signals and corresponding receivers to simulate the processes of signal generation, interference, and reception in the time domain. Baseband equivalence of passband system has been implemented in order to reduce the computational times. Two thesis students have been participating in the research.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Command, Control and Communications

KEYWORDS: Modeling and Simulation, Communications, MATLAB, SIMULINK

ADVANCED PHASED ARRAY ANTENNA TECHNOLOGIES

Chin-Hwa Lee, Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Intelligence

OBJECTIVE: To access performance and costs of advanced phased array antenna technologies in emerging radar systems.

SUMMARY: An analysis program was developed to access the tracking performance of phased array antenna. The study involved investigation of most recent active phased array radar systems in development around the world. The range and tracking performance were examined versus costs that indicate the future trend of the new radar systems.

PUBLICATION:

Lee, C.H., “Decentralized Power Management Algorithm for Frequency Reuse,” *Proceedings of the IEEE MILCOM Conference*, Monterey, CA, November 1997.

THESES DIRECTED:

Nimitbunanan, N., “Video Conferencing Using Packet Radio Technology,” Master’s Thesis, Naval Postgraduate School, June 1997.

Rodrigues, Alfredo, “Probability of Bit Error in Cochannel Interference and Fading,” Master’s Thesis, September 1997.

Sari, M., “Designing Fast Golay Encoder/Decoder in Xilinx XACT with Mentor Graphics CAD Interface,” Master’s Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Radar, Antenna

PROJECT SUMMARIES

RADIO FREQUENCY (RF) MESH NETWORKING AND POWER MANAGEMENT

Chin-Hwa Lee, Professor

Department of Electrical and Computer Engineering

Sponsors: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: Investigate the multiple access technology for Navy UHF high speed links.

SUMMARY: The main accomplishment in the frequency reuse project is the development of the simulation program. The simulation program was improved to test out the traffic capacity of a carrier sensed collision avoidance multi-access system. The main purpose of the multi-access system is to increase the total communication capacity of the Navy ship-to-ship and ship-to-shore UHF links. Throughput and link delay were measured and compared to the theoretical results.

PUBLICATION:

Lee, C.H., "Decentralized Power Management Algorithm for Frequency Reuse," *Proceedings of the IEEE MILCOM Conference*, Monterey, CA, November 1997.

THESIS DIRECTED:

Rodrigues, A., "Probability of Bit Error in Cochannel Interference and Fading," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Command, Control, and Communications, Communication

ELECTROMAGNETIC (EM) SCATTERING FROM A TUBULAR CYLINDER OF ANISOTROPIC SURFACE IMPEDANCES

H.-M. Lee, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: To investigate the effects of impedance coating on the scattering of electromagnetic waves by a body.

SUMMARY: The electromagnetic scattering from a zero-thickness, perfectly conducting, circular, tubular cylinder of finite length with different anisotropic coatings on its inside and outside surfaces is investigated. The induced electric and magnetic surface current densities and the far field are obtained. Analytical expressions of the double series expansion coefficients of the kernels of the integral-differential equations of this problem are found and utilized in the computation to assure that extremely accurate numerical results can be obtained. These results will be used as a standard for validating numerical electromagnetic computation codes.

PUBLICATION:

Lee, H.-M. and Yu, C.-K., "A Theorem of Anisotropic Absorbers," Naval Postgraduate School Technical Report, NPS-EC-97-004, March 1997.

DISSERTATION DIRECTED:

Yu, C.-K., "Electromagnetic Scattering of an Anisotropically Coated Tubular Cylinder," Doctor of Philosophy Dissertation, Naval Postgraduate School, March 1997.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics, Electronic Warfare

KEYWORDS: Radar Cross Section, Sensors, Low Observables

LOW ALTITUDE INFRARED (IR) PROPAGATION ABOVE OCEAN

H.-M. Lee, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: Examine the fluctuation in the strength of low altitude propagation of infrared beam above ocean surface to determine the effects of temperature profile and ocean waves.

SUMMARY: Fluctuation in the received strength of infrared beam transmitted over the ocean surface is investigated. The temperature, wind speed and ocean wave data are used to construct the temperature profile to correlate with the recorded infrared (IR) beam strength information. The results should improve our understanding of the effects of ocean environment on IR sensors.

DISSERTATION DIRECTED:

Yeoh, L.-W., "Low Altitude Optical Propagation Over the Ocean, Volume I and II," Doctor of Philosophy Dissertation, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREAS: Battlespace Environment, Sensors

KEYWORDS: Infrared Sensor, Environmental Effects

DEVELOPMENT OF MOSAIC INFRARED MODELING SYSTEM AND UWB HIGH POWER MICROWAVE JAMMER

Fred Levien, Senior Lecturer

R. Clark Robertson, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Air Warfare Center-Weapons Division

OBJECTIVE: The mosaic infrared modeling and simulation system will be employed in evaluating the survivability of the SH-60B Seahawk helicopter in the new tactical roles envisioned for it. Efforts will continue to establish a closer support relationship between NPS and other EWAT teams to ensure a wider availability of infrared M&S for use in their research. Work will continue on developing tactical tools for delivering UWB expendable jammers to counter military and civilian communication system. Sources will be built and tested configured for both airborne and special forces delivery.

DoD KEY TECHNOLOGY AREA: Other (Infrared Countermeasures)

KEYWORDS: Infrared, Missiles, Ultrawide Band, Jamming, Expendables

PROJECT SUMMARIES

RADAR TERRAIN MASKING ALGORITHM EVALUATION OF TAMPS, AFMSS, AND IMOM

Fred Levien, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Operations Test and Evaluation Force

OBJECTIVE: To support the investigation of radar terrain masking (RTM) generation, and presentation characteristics using three DoD mission planning models, TAMPS, AFMSS, and IMOM. Using theoretical and flight test data collected, establish a criteria level which will be used as part of the joint mission planning system (JMPS) scheduled to be online shortly after the turn of the century.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Simulation Verification, Validation, Accreditation

PROJECT GUSTY ORIOLE, COMPUTER ALGORITHMS AND ARCHITECTURES FOR SPACE APPLICATIONS

Herschel H. Loomis, Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: This project is concerned with the application of computer algorithms to specific military space projects, the development of specialized computer architectures for military space applications and the support of the space operations curriculum.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Military Space, Computer Architectures

INFORMATION OPERATIONS RESEARCH SUPPORT

Gus K. Lott, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: To promote information operations (IO) research among the 30 to 40 cryptologic officers attending NPS. To promote general IO research in all three major areas: protection, exploitation, and attack.

SUMMARY: Work continued on supporting two major Naval Information Warfare Activity (NIWA) projects in the area of geopositioning systems and radio frequency mission planning. In geopositioning, work included simulation of cyclostationary processing techniques to NIWA's multi-platform time difference of arrival system. Geopositioning work also included solution improvement by incorporating real-time space weather information and computerized ionospheric tomography. Radio Frequency Mission Planning (RFMP) work included better propagation prediction by using real-time environmental information. Work also included further refinement of the "Lott Plot" techniques for prediction of mission success.

PUBLICATION:

Lott, G.K., "Navy Requirements for Space Weather Information," *Proceedings of the Space Weather Effects on Propagation of Navigation and Communications Signals*, COMSAT, Bethesda, MD, October 1997.

PROJECT SUMMARIES

CONFERENCE PRESENTATIONS:

Lott, G.K., "Public-Key Cryptography," Annual Atlantic-Fleet Cryptologic Officers Meeting, Norfolk, VA, January 1997.

Lott, G.K., "Tactical Uses of Computerized Ionospheric Tomography," 1st International Conference on Computerized Ionospheric Tomography, Applied Research Laboratory, University of Texas at Austin, Austin, Texas, February 1997.

Lott, G.K., "Computer Modeling for Wireless System Planning," National Association of Telecommunications Officials and Administrators (NATOA), Tucson, AZ, September 1997.

Lott, G.K., "Tactical Applications of and Distribution Means for Near-Real-Time Space Weather Information," Space Weather Effects on Propagation of Navigation and Communications Signals, COMSAT, Bethesda, MD, October 1997.

THESIS DIRECTED:

Streight, D.A., "Application of Cyclostationary Signal Selectivity to the Carry-On Multi-Platform GPS Assisted Time Difference of Arrival System," Engineer's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare, Other (Signals Intelligence, Information Operations)

KEYWORDS: Radio Propagation Modeling, Propagation Model Validation, Computerized Ionospheric Tomography, Time-Difference-of-Arrival, Geopositioning

ASYNCHRONOUS TRANSFER MODE (ATM) COMPRESSED VIDEO BITSTREAM MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Engineering Logistics Office and Naval Postgraduate School

OBJECTIVE: To develop models for efficient processing of compressed video observed over an ATM network. To establish a testbed high-speed network within NPS for testing and evaluation of networked video. It is anticipated that work associated with this effort will be transitioned to the project entitled "Defensive ATM Modeling and Analysis for Information Warfare."

SUMMARY: The initial components for an ATM high-speed video network were identified, procured, installed, and configured resulting in a significant upgrade to the Department of Electrical and Computer Engineering's networking laboratory facilities. The development of this lab has already benefited students in the EC3850 class. A commitment was obtained from the Naval Engineering Logistics Office (NELO) to cover the remaining shortfall in initial proposed DFR funding. The initial taxonomy and algorithms to be used in the analysis of video bitstreams has been developed. Additionally, software from interested DoD agencies has been acquired and installed. Ongoing work involves coding and evaluation of the analysis algorithms.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

PROJECT SUMMARIES

DEFENSIVE ASYNCHRONOUS TRANSFER MODE (ATM) MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To develop models and simulations of standards-based digital communications networks using MILs' OPNET network modeling software environment. To determine infrastructure constraints and vulnerabilities based on simulated results. This work is part of a continuing project with the Naval Engineering Logistics Office (NELO).

SUMMARY: Two subprojects have been identified in relation to this project: (1) IT-21 standards-based modeling for susceptibility analysis and (2) electronic content modeling, recognition, and identification from ATM bitstreams. All of the work on this project has been performed on a Sun Ultra workstation procured, installed, and configured in restricted spaces. With respect to the first topic, a baseline simulation model has been developed for a projected IT-21 standards-based network. Additionally, two initial attack simulations have been developed and are under evaluation. Under the second subproject, several protocol analysis packages were evaluated and modified to all bitstream evaluation. A consolidated suite of tools was formed and installed on the workstation and evaluation is ongoing on synthetic data.

PUBLICATION:

McEachen, J.E., "Defensive ATM Modeling and Analysis for Information Warfare," Naval Postgraduate School Technical Report, NPS-EC-98-006, February 1998.

OTHER

Data Communications Analysis Tools Suite (DCATS). A collection of software protocol analysis tools consolidated at the request of a sponsor (NELO) and forwarded via DCS, 19 December 1997. These software tools allow near-real-time analysis of a large variety of data communication protocols in a user-friendly X-window based environment.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

INTERNET WORKING ANALYSIS FOR COUNTERNARCOTICS INFORMATION OPERATIONS

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: To develop methods for non-traditional analysis of computer network topologies, specifically those affiliated with the Internet. To recommend means for advanced use of network information in information operations. This work is a part of a continuing project with the National Security Agency (NSA).

SUMMARY: This project examines computer network topologies and operations in support of national security interests and is largely classified in nature. Recent initiatives within NSA have produced highly unique data requiring more powerful analysis techniques. The initial stages of this research involved identifying key participants with a potential interest in this information. Additionally, specific areas for investigation were identified for further pursuit by NPS students. Finally, a specific NPS student was identified to conduct analysis of current data and apply it to the area of interest. This student will graduate in September 1998. Ongoing work involves identifying new NPS students for thesis research in the remaining areas of interest and continued analysis of network trends.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Internet, Counternarcotics, Network Analysis

MODELING AND SIMULATION OF ASYNCHRONOUS TRAFIC MODE (ATM) TRANSPORT MECHANISMS IN LARGE-SCALE NETWORKS FOR PROJECTION OF INFORMATION OPERATIONS

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To conduct analysis and evaluation of ATM facilities focusing on vulnerability identification and isolation through development of comprehensive large-scale digital communications network models using MIL3's OPNET network modeling software environment. This work is part of a continuing project with Naval Engineering Logistics Office (NELO).

SUMMARY: Initial efforts on this project have involved analysis of topology information provided by the sponsor. Work on this project began in December 1997.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

ORGANIZATIONAL COLLABORATION IN A GLOBALLY NETWORKED ENVIRONMENT

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: IEEE Circuits and Systems Society

OBJECTIVE: To leverage off-cutting edge Internet technology and to develop a network-centric system that facilitates the fundamental processes of conference organization and planning.

SUMMARY: Professional society conferences—such as the IEEE International Symposium on Circuits and Systems (ISCAS) or the IEEE Military Communications Conference (MILCOM)—are the primary mechanism for exchanging ideas on cutting edge research of vital interest to DoD. This project has identified and encapsulated the collaboration processes associated with organizing such conferences and created a system for researcher interaction on a global scale via the Internet.

Recent advances in database and networking technology allow the traditional processes for conference collaboration to be migrated to an on-line environment. Specifically, the recent development of multi-part MIME encoding, Adobe Portable Document Format (PDF), and Open Database Connectivity (ODBC) world wide web (WWW) gateways led to the implementation of a prototype system which allowed thousands of conference participants to submit documents using standard WWW browsing software for on-line consideration and review. Further, the review process itself as well as presentation scheduling, receipt verification and acknowledgement, and system administration are all facilitated with this system. Traditionally, this had been a highly labor intensive exercise involving several exchanges via postal mail and considerable expense. Some on-line conference organization systems have been implemented in the past, but none have approached the extent and robustness of the current effort.

PROJECT SUMMARIES

PUBLICATION:

Coffman, J.W. and McEachen, J.C., "A Paradigm for Collaboration Across a Globally Networked Environment: Implementation of the ISCAS '98 Internet Services," to appear in the *Proceedings of the 1998 International Symposium on Circuits and Systems*, Monterey, CA, June 1998.

CONFERENCE PRESENTATION:

McEachen, J.C., "A Paradigm for Collaboration Across a Globally Networked Environment: Implementation of the ISCAS '98 Internet Services," to be presented at the 1998 International Symposium on Circuits and Systems, Monterey, CA, June 1998.

OTHER:

ISCAS '98 WWW, E-mail, and Database Servers (<http://iscas.nps.navy.mil/>). A suite of servers was installed and configured for use by the ISCAS organizing committee and participants. These services included mass e-mail announcements, e-mail for committee members, paper submission, review dissemination and collection, scheduling, database access, and program generation. Records on over 3000 individuals were maintained. Over 1200 papers were collected and reviewed. The WWW site was visited over 300,000 times as of December 1997.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface

KEYWORDS: Database, Internet, Common Gateway Interface, World Wide Web (WWW), Networking

RADIATION HARDENING OF SPACE-BASED ELECTRONIC DEVICES AND SOLAR CELLS

Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: To study the space radiation effects on state-of-the-art solar cells including GaAs and InP cells. To investigate annealing methods developed in previous NPS research on the recovery of radiation degraded performance of advanced space cells and develop radiation hardened Analog VLSI circuits for space applications.

SUMMARY: Continuation of the ongoing research on Photovoltaic Power Technology. Research tasks include optimizing current annealing methods previously developed for GaAs cells. The tasks also include investigating of the new laser annealing technique on GaAs and InP solar cells. Irradiating solar cells using NPS Linear Accelerator, and measuring their characteristics using the newly developed Solar Simulator Facilities. Other tasks are to investigate radiation effects on different electronic devices. Radiation testing of Analog VLSI chips previously designed and fabricated, using the NPS Linear Accelerator. Major Research: 1) annealing of radiation-damaged solar cells, 2) investigating of Laser Annealing techniques for radiation-damaged solar cells, and 3) radiation tolerant ASIC and analog IC design, implementation and testing.

PUBLICATIONS:

Michael, S., Shehata, K., and Fouts, D., "Analog/Digital Gallium Arsenide Circuits and Systems Design," *Proceedings of the 40th Midwest Symposium on Circuits and Systems*, Sacramento, CA, August 1997.

Michael, S., Shehata, K., and Fouts, D., "Dynamic Logic Families for Complementary Gallium Arsenide (CgAs) Fabrication Processes," *Proceedings of the 40th Midwest Symposium on Circuits and Systems*, Sacramento, CA August 1997.

PROJECT SUMMARIES

Michael, S. and Oldland, H., "A GaAs Mixed Mode Switched Capacitor VLSI," *Proceedings of the 40th Midwest Symposium on Circuits and Systems*, Sacramento, CA, August 1997.

CONFERENCE PRESENTATION:

Michael, S., "A GaAs Mixed Mode Switched Capacitor VLSI," 40th Midwest Symposium on Circuits and Systems, Sacramento, CA, August 1997.

THESES DIRECTED:

Oldland, H., "The VLSI Implementation of a GaAs GIC Switched Capacitor Filter," Master's Thesis, Naval Postgraduate School, June 1997.

Reason, J., "A Comparative Study of Nuclear Technology and Direct Energy Conversion Methods for Space Power Systems," Master's Thesis, Naval Postgraduate School, June 1997.

DoD KEY TECHNOLOGY AREA: Other (Environmental Effects)

KEYWORDS: Space Radiation Effects, Satellites, Annealing Radiation Hardened

UNINTERRUPTABLE POWER SUPPLY DESIGN FOR THE AN/MRC 142-COMMUNICATION SYSTEM

Sherif Michael, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Marine Corps Systems Command

OBJECTIVE: To design and develop a prototype uninterruptable power supply. The result would be an improved power distribution panel that will provide the capability to manually switch between two AC sources, to the HMMWV DC battery/alternator or other DC sources. This would be accomplished with no interruption in the AN/MRC-142 communication system operation.

SUMMARY: The research project tasks can be summarized as follows:

- 1) Analyze and study the current existing AN/MRC-142 Power Distribution Panel.
- 2) Design and develop an Uninterruptable Power Supply that will perform the following functions:
 - Convert the selected ac source to 28v dc according to specifications.
 - Respond to monitor signals and initiate or terminate HMMWV charging.
 - Manual override switch for selection between either ac generator.
 - Automatic switching between either generator and the HMMWV Batteries.
 - Display panel for monitoring of the UPS operations.
 - Protection against overvoltage of the ac generators.
- 3) Modify the existing PDP to accommodate the above design within the same panel.
- 4) Complete implementation and testing of the developed UPS.

THESIS DIRECTED:

Callahan, W., "The Design, Implementation, and Testing of an Uninterruptable Power Supply for the AN/MRC-142 UHF Radio System," Master's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: AN/MRC-142 USMC Communications System, Uninterruptable Power Supply

PROJECT SUMMARIES

A HIGH DATA RATE COFDM MODE FOR UHF LINE-OF-SIGHT COMMUNICATIONS IN A MARITIME ENVIRONMENT

Paul H. Moose, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: Investigation of high data rate (1.544 Mbps) modem designs for a LOS UHF Naval battle group communications network. The modems will be based on coded orthogonal frequency division multiplexing (COFDM). Appropriate guard intervals, error control coding and interleaving will be determined based on NRD provided channel information, simulation will be used to optimize system parameters.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Communications, Wireless, COFDM

ELECTROMAGNETIC (EM) SIGNATURE SOURCE MEASUREMENT USING SPATIAL SPECTRAL DOMAIN PROCESSING

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: There are three primary objectives of this research: (1) discover a comprehensive theory relating measured EM signatures and source spectral domain radiation contributions on general surfaces; (2) develop enhanced back-propagation algorithms for improved imaging of radiation sources; and (3) validate algorithms using both synthetic data from numerical simulations and measured data from the NPS scattering range and other providers.

Important technical issues involve discovery and development of the most useful technique for implementation with measured data. The form of this transformation is an issue, with integral equation and differential equation (e.g., finite element) based approaches possible, as well as hybrid methods. On-surface descriptions of signature sources can include physical currents or, more generally, equivalent currents (useful for apertures and volume sources such as penetrable composite materials). Algorithm robustness is a most important issue for real-world operation. Error propagation to source images induced by noise and inaccuracies in acquired data requires detailed quantification.

SUMMARY: This effort supports future ship survivability by furthering the evolution of measurement procedures and data processing for ship EM signature characterization. Accurate localization and identification of radiation sources from both scattering (RCS) and emitters is essential for their mitigation in the design, construction and maintenance of future low-observable platforms operating in an increasingly sophisticated enemy sensor environment.

PUBLICATION:

Morgan, M.A., "Electromagnetic Radiation Source Imaging," Project Report No. 2, Office of Naval Research, Code 334, August 1997.

CONFERENCE PRESENTATION:

Morgan, M.A. and Wawrzyniak, D.J., "Enhanced Electro-Magnetic (EM) Radiation Source Imaging," Progress in Electromagnetics Research (PIER) Symposium, Cambridge, MA, 7-11 June 1997.

PROJECT SUMMARIES

THESIS DIRECTED:

Wawrzyniak, D.J., "Enhanced Electro-Magnetic (EM) Radiation Source Imaging," Master's Thesis, Naval Postgraduate School, June 1997.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Imaging, Back-Propagation, Diffraction Limit

IMPULSE ANTENNA MODELING

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: The goal of this task is to investigate the impulse radiation characteristics of specified antenna structures

SUMMARY: Initial wire-grid numerical modeling of antenna structures has been completed using frequency-stepping. Impulse source modeling has been approached independently from both frequency- and time-domains to form Thevenin equivalent circuits for impulsive sources. Responses from these distinct source models have been shown to agree. Impulse response characterization of antenna structures is accomplished via inverse transformation of an equivalent circuit.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Impulse Response, Antenna Modeling

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

Michael A. Morgan, Professor

R. Clark Robertson, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: The goal of this project was to perform engineering design for efficient, small-sized prototypical ultra-wideband impulse receiving antennas.

SUMMARY: A Method-of-Moments numerical model was developed as an aid to search for optimum geometrical dimensions and resistive tapers to achieve the challenging 10 MHz operation criterion, given the antenna size constraint. Several prototype TEM horns were modeled and performance evaluations conducted. Design specifications were provided to the Army Research Lab for fabrication and testing.

PUBLICATION:

Morgan, M.A. and Robertson, R.C., "Optimized TEM Horn Impulse Receiving Antenna," in *Ultra-Wideband, Short-Pulse Electromagnetics 3*, L. Carin and L.B. Felsen, eds., Plenum Press, New York, pp. 121-128, 1997.

THESIS DIRECTED:

Adamiak, D.V., "Transient Field Visualization for Ultra-Wideband Antenna Design," Masters Thesis, Naval Postgraduate School, December 1997.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ultra-Wideband, Impulse Antennas, TEM Horns

EXPERIMENTAL INVESTIGATION OF A HIGH-SPEED HIGH-RESOLUTION DIRECTION FINDING ARRAY

Phillip E. Pace, Associate Professor

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force and Naval Postgraduate School

OBJECTIVE: A direction finding (DF) antenna employing an optimum symmetrical number system (OSNS) encoding of the interferometer phase response to an incident plane wave was developed. The DF method is capable of providing high resolution instantaneous angle of arrival estimates over a wide field of view. In the study just completed (Phase II), a three-channel array was built, and measurements taken in the NPS anechoic chamber to verify the concept and the array performance capabilities.

SUMMARY: Interferometer DF systems provide an emitter's bearing that can be used as a sorting parameter in the identification of radar and communication systems. There is a fundamental tradeoff between the array length and its resolution limit. Conventional techniques to shorten the array lead to ambiguous angle measurements. This research involves the development of a new type of DF array based on the optimum symmetrical number system. The DF antenna architecture being investigated uses the OSNS to decompose the analog spatial filtering operation into a number of parallel sub-operations (moduli) that are of smaller complexity. One two-element interferometer is used for each sub-operation and it only requires a precision in accordance with its modulus. A much higher spatial resolution is achieved after the spatial filtering results of these low precision sub-operations are combined. Thus a very short array can instantaneously determine the direction of arrival for an emitter with high precision.

PUBLICATIONS:

Pace, P. E., Styer, D., and Akin, I. A., "A Folding ADC Using a Robust Symmetrical Number System with Gray Code Properties," *Proceedings of the 1998 IEEE International Symposium on Circuits and Systems*, accepted for publication, June 1998.

Pace, P. E., Styer, D., and Ringer, W. P., "Optimum SNS to Binary Conversion Algorithm and FPGA Realization," *Proceedings of the 1998 IEEE International Symposium on Circuits and Systems*, accepted for publication, June 1998.

OTHER:

Pace, P. and Jenn, D., "Experimental Investigation of a High-Speed High-Resolution Direction Finding Array," Progress Report, 1 July 1997.

PATENT:

Pace, P. E., "High Resolution Encoding Circuit and Process for Analog to Digital Conversion," U.S. Patent Number 5,617,092, 1 April 1997.

THESES DIRECTED:

Akin, I.A., "A Robust Symmetrical Number System With Gray Code Properties for Applications in Signal Processing," Master's Thesis, Naval Postgraduate School, September 1997.

PROJECT SUMMARIES

Papandreou, P., "Design and Prototype Development of an Optimum Symmetrical Number System Direction Finding Array," Master's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Array Antennas, Direction Finding, Symmetrical Number Systems

OPTICAL SAMPLING OF MICROWAVE SIGNALS

Phillip E. Pace, Associate Professor

John Powers, Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: To study the issues involved in using optical pulses from a mode-locked laser to sample radio frequency and microwave signals using electro-optical devices. Optical oversampling and undersampling architectures were to be studied. Also, nonuniform sampling theory formulation of the jitter phenomenon was to be studied.

SUMMARY: The pulse width and jitter power of the various lasers as reported in the literature were examined in order to study their applicability for use as a wideband signal sampling source. A mode-locked fiber sigma laser has been designed for use in studying the effects of laser pulse sampling of wideband signals. This laser configuration is promising for direct signal sampling since the jitter component has been estimated at less than 200 fs. In addition, optical techniques for measuring the output of the mode-locked lasers have been reviewed. For higher resolution in the detected optical pulse, several optical oversampling (sigma-delta) architectures have been investigated. These optical processors conveniently trade off sampling rate for resolution. Simulation studies were conducted to determine the required coupling coefficients for the fiber lattice configurations. Both first- and second-order, single-bit architectures have been investigated. These architectures are encouraging because they relax the mode-locked laser pulse jitter requirements since the sampling errors are integrated out of the signal band using feedback. If the signal is sampled below the Nyquist rate (undersampling), frequency ambiguities arise. In our work, the symmetrical number system (SNS) was found to have the same form as the discrete Fourier transform (DFT). Using this relationship, DFT receivers have been designed to resolve the undersampling ambiguities exactly. Several optical DFT receivers have been initially investigated. Nonuniform sampling theory has also been investigated as a formulation to describe the effects of sampling jitter that occur due to laser noise. Iterative algorithms for removing the jitter component from the sampled signal have also been initially investigated.

PUBLICATIONS:

Pace, P.E., Ringer, W.P., Foster, K.D., and Powers, J.P., "Optical Signal Integrity and Interpolation Signal Processing in Wideband SNS Digital Antennas," *Proceedings of the 7th Annual DARPA Symposium on Photonic Systems for Antenna Applications*, pp. 112-117, 13 January 1997.

Pace, P.E., Atherton, A.F., and Powers, J.P., "Integrated Optical Accumulators with Applications in Sigma Delta Modulation," *Proceedings of the 7th Annual DARPA Symposium on Photonic Systems for Antenna Applications*, pp. 150-154, 13 January 1997.

Pace, P.E., Leino, R., and Styer, D., "Use of the Symmetrical Number System in Resolving Single Frequency Undersampling Ambiguities" *IEEE Transactions on Signal Processing*, Vol. 45, pp. 1153-1160, May 1997.

CONFERENCE PRESENTATIONS:

Pace, P.E., Ringer, W.P., Foster, K.D., and Powers, J.P., "Optical Signal Integrity and Interpolation Signal Processing in Wideband SNS Digital Antennas," 7th Annual DARPA Symposium on Photonic Systems for Antenna Applications, Monterey, CA, 13 January 1997.

PROJECT SUMMARIES

Pace, P.E., Atherton, A.F., and Powers, J.P., "Integrated Optical Accumulators with Applications in Sigma Delta Modulation," 7th Annual DARPA Symposium on Photonic Systems for Antenna Applications, Monterey, CA, 13 January 1997.

Pace, P.E., "Optical Sampling and Direct Digitization of Wideband Antenna Signals," Naval Surface Warfare Center-Crane, Monterey, CA, 30 September 1997.

THESES DIRECTED:

Atherton, A.F., "Integrated Optical Fiber Lattice Accumulators," Master's Thesis, Naval Postgraduate School, March 1997.

Foster, K.D., "A 3-Channel 14-Bit Optimum SNS Wideband Digital Antenna: Analysis of the Electro-Optic Sampling Front-End," Master's Thesis, Naval Postgraduate School, September 1997.

Ringer, W.P., "Design, Construction and Analysis of a 14-Bit Direct Digital Antennal Utilizing Optical Sampling and Optimum SNS Encoding," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Sensors, Electronic Warfare, Other (Optics)

KEYWORDS: Optical Sampling, Undersampling, Oversampling, Jitter

IMPROVEMENT IN ANTI-SHIP CRUISE MISSILE (ACSM) THREAT SIMULATOR MODELING AND SIMULATION TECHNOLOGY

Phillip E. Pace, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: To continue the effort to develop signal processing routines to improve effectiveness calculations (miss distance) for ship board self-defense systems against hardware-in-the-loop (HIL) anti-ship cruise missile (ASCM) simulators. A second continuing objective in support of the DoN's ASCM Simulator Validation Working Group is the development of software routines that automatically extract a number Electronic Warfare Integrated Reprogrammable Database (EWIRDB) parameters from simulator characterization data obtained in the Naval Research Laboratory (NRL) Central Target Simulator (CTS) anechoic chamber facility.

SUMMARY: Distributed sensor, time-space-position information algorithms were further developed for the NRL P-3 research aircraft. These algorithms fuse together the aircraft's onboard global positioning system data, the inertial navigation system data and the HIL missile simulator targeting files in order to graphically display (and tag) in geodetic coordinates, the experimental results from the captive-carry range tests. Lever-arm corrections were computed for each HIL missile simulator and its corresponding mount position on the NRL P-3 research aircraft. To evaluate the differences between the captive-carry missile experiments and an actual threat engagement, computer simulations of a missile attack on a ship that fires a NULKA were carried out in a classroom computer assignment (EC3700). Evaluation of the seeker response as a function of the test geometry was investigated. Correlation of the seeker response curves provided further insight into how effectiveness calculations can be accurately obtained from the captive-carry experiments. To help support the DoN's ASCM simulator validation effort, software routines to extract five additional EWIRDB parameters from the simulator's CTS characterization data were added to the Automatic Extraction of Threat Simulator Critical Parameters (AETSCP) software. The AETSCP version 2.0 now extracts 44 EWIRDB parameters automatically and compares them with the values contained within the intelligence database.

PUBLICATIONS:

Gill, C.W. and Pace, P.E., "Neural Prediction of Missile Dynamics During Hardware in the Loop Captive-Carry Experiments," *Proceedings of the IEEE International Conference on Neural Networks*, pp. 2208-2212, Houston TX, June 1997.

PROJECT SUMMARIES

Pace, P.E., Nishimura, B.H., Morris, W.M., and Surratt, R.E., "Effectiveness Calculations in Captive-Carry HIL Missile Simulator Experiments," *IEEE Transactions on Aerospace and Electronic Systems*, February 1997.

Pace, P.E., Welch, M., and Zulaica, D., "AETSCP Matlab Toolbox Version 2.0," Naval Research Laboratory *NRL Memorandum Code 5760*, 10 March 1997.

Pace, H., Robertson, R.C., and Pace, P.E., "Frequency Management and Anti-Jam Communication Technologies for the Battlefield," *Proceedings of the 1997 Association of Old Crows Western Region IW Technical Symposium*, pp. 229-235, San Antonio, TX, April 1997.

Pace, P.E., "Distributed Sensor TSPI Algorithm P-3 Implementation," Naval Research Laboratory *NRL Memorandum Code 5760*, 5 August 1997.

Pace, P.E., and Zulaica, D.P., "Automatic Extraction of Threat Simulator Critical Parameters Matlab Toolbox," Naval Postgraduate School Technical Report, NPS-EC-97-012, October 1997.

Pace, H. and Pace, P. E., "Frequency Management for the 21st Century," *Journal of Electronic Defense*, accepted for publication, December 1997.

CONFERENCE PRESENTATIONS:

Gill, C.W. and Pace, P.E., "Neural Prediction of Missile Dynamics During Hardware in the Loop Captive-Carry Experiments," poster presentation, 1997 IEEE International Conference on Neural Networks, Houston, TX, 9 June 1997.

Pace, H., Robertson, R.C., and Pace, P.E., "Frequency Management and Anti-Jam Communication Technologies for the Battlefield," 1997 Association of Old Crows Western Region IW Technical Symposium, San Antonio, TX, 21 April 1997.

Pace, P.E. and Welch, M.J., "AETSCP Version 2.0," Simulator Validation Working Group, Naval Research Laboratory, Washington, DC, 12 May 1997.

THESIS DIRECTED:

Welch, M.J., "Automatic Extraction of Threat Simulator Critical Parameters Version 2.0 (U)," Master's Thesis, Naval Postgraduate School, June 1997, (SECRET).

OTHER:

Pace, P.E., "Automatic Extraction of Threat Simulator Critical Parameters Version 2.0," Matlab Software, June 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare, Modeling and Simulation

KEYWORDS: Time-Space-Position Information, Sensor Fusion, EWIRDB, Hardware-in-the-Loop, Missile Simulation, Effectiveness Calculations

PROJECT SUMMARIES

MULTI-TARGET/MULTI-SENSOR FUSION PROCESSING TECHNIQUES

Harold Titus, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: CAPT Richard Williamson and LT Mike Fallon finished work on the emitter location algorithms project. One of the central problems in initializing the location and associating it with an existing file of targets of interest. This still requires more work. We will provide a general sensor fusion algorithm (via extended Kalmar filtering). This should give geolocations based on observations of interest. Implementing the algorithm is hypothesized with differential GPS units collocated with the sensors.

DoD KEY TECHNOLOGY AREA: Other (Communications Networking)

KEYWORDS: Extended Kalmar Filtering, Sensor Fusion, FFT Processing, Neural Networks

BEARTRAP POST-MISSION ANALYSIS SYSTEM

Murali Tummala, Professor

Charles W. Therrien, Professor

Department of Electrical and Computer Engineering

Sponsor: Advanced Maritime Projects Office and Naval Postgraduate School

OBJECTIVE: To design and develop a signal processing system capable of implementing narrowband frequency tracking, multi-target tracking, wideband and swath processing, transient analysis, and data fusion for the Beartrap post-mission analysis.

SUMMARY: The system is being developed based on commercial-off-the-shelf technology: PentiumPro based PC with Windows NT operating system. The user interface is being developed using Microsoft Visual C++, and all the processing algorithms are being coded in the C++ language as well.

During 1997, several user interface screens have been designed. Hardware interface designs have been developed and partially implemented. The narrowband analysis software (AQL) modules have been developed in C++ to carryout filter and decimation, multi-target tracking, frequency track estimation, and SPL estimation functions. Some of these functions were tested by porting the code to the DSP hardware system based on SHARC DSP processors. Work has been carried out on transient analysis algorithms.

THESES DIRECTED:

Horning, Eric R., "Implementation of Narrowband SPL Estimation Algorithm in a Personal Computer Environment," Master's Thesis, Naval Postgraduate School, September 1997.

Mauser, J.D., "Development of an Acoustic Transient Analysis user Interface for Detection and Target Localization," Master's Thesis, Naval Postgraduate School, December 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Computing and Software, Human Systems Interface, Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: Signal Processor Design, Acoustic Signal Processing, Graphical User Interface Design

PROJECT SUMMARIES

PREDISTORTION TECHNIQUES FOR HIGH POWER AMPLIFIERS

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: To develop new techniques for predistortion of high power amplifiers used in line of sight wireless links. Earlier effort was based on neural network, polynomial approximation, and Volterra methods.

SUMMARY: During 1997, work was continued on a Volterra series based algorithm to directly estimate the inverse power amplifier model parameters, which were then used to realize the predistorter. Experiments were conducted to test the order of nonlinearity and the depth of memory needed to satisfactorily compensate the power amplifier nonlinear behavior. A FET power amplifier simulated in P-Spice was considered for obtaining data for testing the algorithm.

PUBLICATION:

Tummala, M., Donovan, M., Watkins, B., and North, R., "Predistortion of High Powered Amplifiers Using Inverse Volterra Modeling," *Proceedings of the 1997 IEEE International Conference on Acoustics, Speech, and Signal Processing*, Munich, Germany, 21-24 April 1997.

CONFERENCE PRESENTATION:

Tummala, M., Donovan, M., Watkins, B., and North, R., "Predistortion of High Powered Amplifiers Using Inverse Volterra Modeling," 1997 IEEE International Conference on Acoustics, Speech, and Signal Processing, Munich, Germany, 21-24 April 1997.

DoD KEY TECHNOLOGY AREAS: Sensors, Command, Control, and Communications

KEY WORDS: High Power Amplifiers, Wireless Communications, Predistortion

DATA FUSION ALGORITHMS FOR VESSEL TRAFFIC SYSTEM

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Coast Guard

OBJECTIVE: To develop data fusion algorithms based on fuzzy association techniques for use in U.S. Coast Guard vessel traffic system upgrade project.

SUMMARY: Vessel Traffic System (VTS) receives data from multiple sensors of different types: multiples radars, differential global positioning system based ADS receivers, acoustic sensors, and synthetically generated standard routes. Multiple sensors tracking the same target generate a large amount of redundant data. Here we have developed fuzzy association based algorithms to fuse data from multiple sensors. The algorithm was tested using field recorded data from Puget Sound, WA.

PUBLICATIONS:

Aziz, A., Tummala, M., and Cristi, R., "Optimal Data Fusion Strategies for Multiple Sensor Systems," *Proceedings of the 31st Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, 2-5 November 1997.

Tummala, M., Midwood, S., and Glenn, I., "Multisensor Data Fusion Using Fuzzy Associative Techniques," *Proceedings of the 1997 Midwest Symposium on Circuits and Systems*, August 1997.

PROJECT SUMMARIES

Tummala, M. and Midwood, S., "Multisensor Data Fusion for the Vessel Traffic System," Naval Postgraduate School Technical Report, under preparation, January 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Sensors

KEYWORDS: Data Fusion, Fuzzy Logic, Multiple Sensors

OPNET SIMULATION OF A MACRO-CELL WIRELESS NETWORK

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: To develop OPNET simulation and modeling of a macro-cell wireless communications network for integrated services (speech and data).

SUMMARY: This work supported the Space and Naval Warfare Systems-Naval Research Laboratory (NRL) joint effort on expeditionary warfare mobile networking. Developed a completed simulation module in OPNET for a DS-CDMA based macro-cell for combined speech and data services.

PUBLICATIONS:

Uziel, A. and Tummala, M., "Modeling of Low Data Rate Services for Mobile ATM," *Proceedings of 1997 International Symposium on Personal, Indoor and Mobile Radio Communications*, pp. 194-198, Helsinki, Finland, 1-4 September 1997.

Uziel, A. and Tummala, M., "Protocol Architecture for Tactical Integrated Services Mobile Networks," *Proceedings of MILCOM'97*, pp. 1532-1536, Monterey, CA, 2-5 November 1997.

THESIS DIRECTED:

Standfield, R., "OPNET Implementation of Spread Spectrum Network for Voice and Data Distribution," Master's Thesis, Naval Postgraduate School, December 1997.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software

KEYWORDS: Code Division Multiple Access, Wireless Communication Networks, Asynchronous Transfer Mode, Integrated Services Digital Networks

LORAN-C: CALOC TIME DIFFERENCE ERROR CONTROL

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Coast Guard

OBJECTIVE: To develop algorithms for estimation and control of time difference error in LORAN-C receivers to replace the existing CALOC system.

SUMMARY: This work is part of the Coast Guard's Loran-C reengineering effort, both transmitter and receiver circuits. Two algorithms (proportional integral differential controller and Kalman filter) were developed for improved estimates of time difference error in the receiver to replace the existing algorithm (called CALOC).

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications

KEYWORDS: Time Difference Error, PID Controller, Kalman Filter

SEU IMMUNE LOW TEMPERATURE GROWN GaAs INTEGRATED CIRCUITS

Todd Weatherford, Assistant Professor

Douglas Fouts, Associate Professor

Department of Electrical and Computer Engineering

**Sponsors: Space and Naval Warfare Systems Command, Naval Research Laboratory, and
Naval Postgraduate School**

OBJECTIVE: To harden digital gallium arsenide (GaAs) integrated circuits to space radiation by reengineering semiconductor starting material.

SUMMARY: The purpose of the program is to implement changes in the semiconductor material in GaAs digital fabrication processes to radiation harden circuits against single event upsets (or soft errors) induced by cosmic radiation. The growth of a sub micron thickness buffer layer internal to a GaAs wafer is utilized to increase recombination of charge induced by high energy penetrating particles. Earlier results in this program with Honeywell has shown that the sensitivity of space-based GaAs ICs can be reduced by 5 to 8 orders of magnitude, sufficiently greater than the 3 to 5 orders of magnitude needed for present digital GaAs technologies. However, manufacturing GaAs ICs over these buffer layers must not require substantial changes in present processing. In addition, the reproducibility of the buffer layers and epitaxial material above the buffers must be consistent from wafer lot to wafer lot grown by commercial GaAs wafer vendors (QED and Picogiga). Efforts in FY97 have focused closely on the effects of implementing the buffer layer to improve yield and performance in both the Motorola and Vitesse GaAs processes.

PUBLICATIONS:

Fouts, D.J., Weatherford, T.R., Dale, C.J., Marshall, P.W., Dietrich, H.B., McMorrow, D., Abrokwhah, J., LaMacchia, M., and Milano, R., "Soft-Error Immune Gallium Arsenide ICs Using COTS Designs and Foundries," *Government Microcircuit Applications Conference*, pp. 93-96, Las Vegas, NV, 10-13 March 1997.

LaMacchia, M., Abrokwhah, J., Bernhardt, B., Foster, D., Crawford, B., Mathes, B., McGuire, T., and Weatherford, T., "Radiation Hardened Complementary GaAs (CGaAsTM)," *IEEE GaAs IC Symposium Technical Digest*, October 1997.

McMorrow, D., Melinger, J.S., Knudson, A.R., Buchner, S., Tran, L.H., Campbell, A.B., Weatherford, T.R., Fouts, D.J., and Curtice, W.R., "Development of a High-Performance Radiation-Immune GaAs Technology Using Low-Temperature Grown GaAs," *Ultrafast Phenomena Workshop*, 18 March 1997.

Pieper, R.J. and Weatherford, T.R., "An Exact Analysis for Bimolecular Band-to-Band Recombination Lifetime Under High Injection Conditions," *Proceedings of the 29th Southeastern Symposium on System Theory*, 9-11 March 1997.

Weatherford, T.R., Marshall, P.W., Marshall, C.J., Fouts, D.J., Mathes, B., and LaMacchia, M., "Effects of Low-Temperature Buffer-layer Thickness and Growth Temperature on the SEE Sensitivity of GaAs HIGFET Circuits," *IEEE Transactions on Nuclear Science*, NS-45, December 1997.

Weatherford, T.R., Radice, R., Devers, J., Eskins, D., Fouts, D.J., Marshall, P.W., Marshall, C.J., Dietrich, H., Twigg, M., and Milano, R., "SEU Design Considerations for MESFETs on LT GaAs," *IEEE Transactions on Nuclear Science*, NS-45, December 1997.

Weatherford, T.R., Fouts, D.J., Marshall, P.W., Marshall, C.J., and Dietrich, H., "Soft Error Immune GaAs Circuit Technologies," *Proceeding of the 1997 Midwest Symposium on Circuits and Systems*, August 1997.

PROJECT SUMMARIES

CONFERENCE PRESENTATIONS:

Fouts, D.J., Weatherford, T.R., Marshall, P.W., Marshall, C.J., Dietrich, H.B., Twigg, M., LaMacchia, M., Abrokwah, J., and Milano, R., "Low-Temperature Gallium Arsenide Soft-Error Immune Digital Integrated Circuits," 1997 Radiation Environmental Effects Forum, Chantilly, VA, 25-27 February 1997.

Pieper, R.J. and Weatherford, T.R., "An Exact Analysis for Bimolecular Band-to-Band Recombination Lifetime Under High Injection Conditions," 29th Southeastern Symposium on System Theory, 9-11 March 1997.

Weatherford, T.R., Marshall, P.W., Marshall, C.J., Fouts, D.J., Mathes, B., and LaMacchia, M., "Effects of Low-Temperature Buffer-layer Thickness and Growth Temperature on the SEE Sensitivity of GaAs HIGFET Circuits," poster presentation, IEEE Natural Space Radiation Effects Conference, Snowmass Village, CO, 21-25 July 1997.

Weatherford, T.R., Radice, R., Devers, J., Eskins, D., Fouts, D.J., Marshall, P.W., Marshall, C.J., Dietrich, H., Twigg, M., and Milano, R., "SEU Design Considerations for MESFETs on LT GaAs," IEEE Natural Space Radiation Effects Conference, Snowmass Village, CO 21-25 July 1997.

Weatherford, T.R., Fouts, D.J., W.Marshall, P.W., Marshall, C.J., and Dietrich, H., "Soft Error Immune GaAs Circuit Technologies," Midwest Symposium on Circuits and Systems, Sacramento, CA, 3 August 1997.

PATENT:

Weber, E., Specht, P., and Weatherford, T.R., "III-V Device Buffer Layers Using Dopants During Low Temperature Growth," November 1997.

THESES DIRECTED:

Eskins, D., "Design and Simulation of a Low Temperature GaAs MESFET," Master's Thesis, Naval Postgraduate School, June 1997.

Radice, R., "Single Event Analysis of LT GaAs MESFET Integrated Circuits," Master's Thesis, Naval Postgraduate School, September 1997.

Schumberger, M., "Single Event Analysis of Low Temperature Gallium Arsenide Field Effect Transistor Technology," Master's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics, Materials, Processes and Structures, Manufacturing Science and Technology, Modeling and Simulation

KEYWORDS: Gallium Arsenide, Radiation Effects, Semiconductors

**HIGH PERFORMANCE, RADIATION HARDENED
INTEGRATED CIRCUIT (IC) TECHNOLOGIES**
Todd Weatherford, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To investigate the radiation hardness of InP, GaAs and SiGe state-of-the-art electronic technologies for use in military space environments.

PROJECT SUMMARIES

SUMMARY: Experiments utilized femtosecond lasers with photoconductive sampling probes to measure the first recorded radiation induced in-situ voltage transients internal to an integrated circuit. Facilities at the University of Michigan's Center of Ultrafast Science were utilized for the laser experiments and computer modeling of the underlying charge transport mechanisms were performed at NPS. The research examined three types of technologies, the Vitesse digital GaAs process and Hughes InP Heterojunction and IBM SiGe bipolar processes. Successful results have enabled the radiation effects community to use this technique to understand the effects of cosmic ray interaction on digital circuits operating at gigahertz frequencies. Additionally the program has been expanded to include other sponsors in FY98.

PUBLICATIONS:

David, G., Hayden, J., Lai, R.K., Ledbetter, E.J., Weatherford, T.R., Fouts, D., and Whitaker, J.F., "Detection of Optically Induced Single-Event Effects Inside Digital Circuits Using a Micromachined Photoconductive Probe," *Proceedings of the 1997 Laser Electro Optics Conference*, San Francisco, CA, November 1997.

Ledbetter, E.J., Weatherford, T.R., David, G., Hayden, J., Lai, R., Whitaker, J., and Fouts, D., "In Situ Picosecond Resolution Measurements of Charge Collection Transients in GaAs Logic," 2nd review, *IEEE Transactions on Nuclear Science*.

Weatherford, T.R., David, G., Whitaker, J., Jobe, K., and Elliott, K., "Charge Collection in InP Heterojunction Bipolar Circuits," to be submitted to the *IEEE Transactions on Nuclear Science*.

CONFERENCE PRESENTATIONS:

David, G., Hayden, J., Lai, R.K., Ledbetter, E.J., Weatherford, T.R., Fouts, D., and Whitaker, J.F., "Detection of Optically Induced Single-Event Effects Inside Digital Circuits Using a Micromachined Photoconductive Probe," 1997 Laser Electro Optics Conference, San Francisco, CA, November 1997.

Ledbetter, E.J., Weatherford, T.R., David, G., Hayden, J., Lai, R., Whitaker, J., and Fouts, D., "In Situ Picosecond Resolution Measurements of Charge Collection Transients in GaAs Logic," poster presentation, IEEE Natural Space Radiation Effects Conference, Snowbird, UT, July 1997.

THESIS DIRECTED:

Ledbetter, E., "Field-Sensitive Photoconductive Sampling Probe Measurements of a Single Event Upset," Master's Thesis, Naval Postgraduate School, June 1997.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes and Structures, Modeling and Simulation

KEYWORDS: Radiation Effects, Indium Phosphide, Gallium Arsenide

COORDINATION OF MOBILE MANIPULATORS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: National Science Foundation

OBJECTIVE: The objective of this project is to investigate control algorithms for coordinating locomotion and manipulation of mobile manipulators.

SUMMARY: A mobile manipulator consisting of a mobile platform and a manipulator combines the dexterous manipulation capability offered by a multi-link manipulator and the mobility provided by a mobile platform. Integration of a manipulator and a mobile platform, however, gives rise to many new issues. In this project, a family of control algorithms were developed for coordinating locomotion and manipulation, based on a novel concept of the preferred operating regions.

PROJECT SUMMARIES

These algorithms were implemented on an experimental mobile manipulator and shown to be very effective in performing various tasks. Dynamic interactions between a mobile platform and its onboard manipulator were investigated. The effect of dynamic interactions on tracking accuracy was obtained. Criteria were established for proper compensation of interactive forces with respect to task requirements. Using superquadric potential functions, an obstacle avoidance scheme for mobile manipulators was developed and integrated with coordinated control algorithms. A control algorithm for coordinating two mobile manipulators was also developed and tested on an experimental system. The system successfully performed a variety of tasks including transporting basketballs and large cartons from one location to another.

PUBLICATIONS:

Sarkar, N., Yun, X., and Kumar, V., "Control of Contact Interactions with Acatastatic Nonholonomic Constraints," *International Journal of Robotics Research*, Vol. 16, No. 3, pp. 357-374, June 1997.

Yamamoto, Y. and Yun, X., "A Modular Approach to Dynamic Modeling of a Class of Mobile Manipulators," *International Journal of Robotics and Automation*, Vol. 12, No. 2, pp. 41-48, 1997.

Yun, X. and Yamamoto, Y., "Stability Analysis of the Internal Dynamics of a Wheeled Mobile Robot," *Journal of Robotic Systems*, Vol. 14, No.10, pp. 697-709, October 1997.

THESIS DIRECTED:

Gerrard, D., "Dynamic Control of a Vehicle with Two Independent Wheels," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Sensors, Ground Vehicles, Modeling and Simulation

KEYWORDS: Mobile Manipulators, Coordination, Control

CISE RESEARCH INSTRUMENTATION: EXPERIMENTAL STUDY OF MULTIPLE MOBILE MANIPULATORS

Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Science Foundation

OBJECTIVE: The objective of this equipment grant was to support three research projects: (1) force and motion control for intelligent exploration of environments; (2) coordination of locomotion and manipulation; and (3) coordination of multiple mobile manipulators.

SUMMARY: All three projects have been successfully carried out. Significant results have been obtained. First, a new force/motion control algorithm based on impulsive constraint analysis was developed and experimentally validated. This algorithm eliminates control discontinuities present in most other force controllers. Second, a family of control algorithms were developed for coordinating locomotion and manipulation, based on a novel concept of the preferred operating regions. These algorithms were implemented on an experimental mobile manipulator and shown to be very effective in performing various tasks. Third, a control algorithm for coordinating two mobile manipulators was developed and tested on an experimental system. The system successfully performed a variety of tasks including transporting basketballs and large cartons from one location to another.

PUBLICATIONS:

Sarkar, N., Yun, X., and Kumar, V., "Dynamic Control of 3-D Rolling Contacts in Two-Arm Manipulation," *IEEE Transactions on Robotics and Automation*, Vol. 13, No. 3, pp. 364-376, June 1997.

PROJECT SUMMARIES

Sarkar, N., Yun, X., and Ellis, R., "Live-Constraint-Based Control for Contact Transitions," *Proceedings of the 1997 IEEE International Symposium on Computational Intelligence in Robotics and Automation*, pp. 353-360, Monterey, CA, July 1997.

Yun, X., Alptekin, G., and Albayrak, O., "Line and Circle Formation of Distributed Physical Mobile Robots," *Journal of Robotic Systems*, Vol. 14, No. 2, pp. 63-76, February 1997.

CONFERENCE PRESENTATION:

Yun, X., "A Survey of Wheeled Mobile Robots," ICRA'97 Workshop on Innovative Designs of Wheeled Mobile Robots, Albuquerque, NM, 20 April 1997.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Robotic Technology)

KEYWORDS: Robot Manipulators, Force Control, Impulsive Constraints

FEATURE-BASED LOCALIZATION AND NAVIGATION OF AUTONOMOUS MOBILE ROBOTS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Research

OBJECTIVE: To investigate localization and navigation of mobile robots using sonars and laser-range finders.

SUMMARY: For an autonomous mobile robot to navigate in an unknown environment, it is essential to know the location of the robot on a real-time basis. Finding position and orientation of a mobile robot in a world coordinate system is a problem in localization. Dead-reckoning is commonly used for localization, but position and orientation errors from dead-reckoning tend to accumulate over time. This project develops a feature-based localization method that allows a mobile robot to re-calibrate its position and orientation by automatically selecting wall-like features in the environment. The selection of features is accomplished by applying the Hough transform to sonar data. The Hough transform makes it possible to select the optimal feature (the longest wall, in this case) without finding all possible line segments from the sonar data. A least-square line fitting method is then employed to construct a model of the line segment that represents the feature selected by the Hough transform. The algorithm developed was tested using synthetic and real sonar data. Experimental results demonstrated the effectiveness of the proposed localization methods.

PUBLICATION:

Yun, X. and Tan, K.-C., "A Wall-Following Method for Escaping Local Minima in Potential Field Based Motion Planning," *Proceedings of the 8th International Conference on Advanced Robotics*, pp. 421-426, Monterey, CA, July 1997.

CONFERENCE PRESENTATION:

Yun, X., "A Wall-Following Method for Escaping Local Minima in Potential Field Based Motion Planning," 8th International Conference on Advanced Robotics, Monterey, CA, July 1997.

THESES DIRECTED:

Latt, K., "Sonar-Based Localization of Mobile Robots Using the Hough Transform," Master's Thesis, Naval Postgraduate School, March 1997.

PROJECT SUMMARIES

Schmidt, J.A., "Design, Construction and Testing of an Autonomous Mine Hunter," Master's Thesis, Naval Postgraduate School, December 1997.

DoD KEY TECHNOLOGY AREAS: Ground Vehicles, Other (Robotic Technology)

KEYWORDS: Mobile Robots, Localization, Navigation

WIRELESS DAMAGE CONTROL COMPUTER NETWORK

Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: To develop a wireless computer network for submarine damage control.

SUMMARY: Accurate, timely communications between the casualty scene, different stations around the ship, and damage control central (DCC) have always been of the utmost importance when combating shipboard casualties. Current damage control communications practices aboard submarines rely on a slow, error prone process involving sound powered telephone talkers and grease pencil annotated status boards. This project is aimed at greatly improving the speed and reliability of these communications by supplementing the current DCC communication methods with a wireless Local Area Network (LAN) that allows portable computers at the scene of casualty and elsewhere around the ship to remotely update the casualty status at DCC.

THESIS DIRECTED:

Bekas, A.J., "Wireless Communications for a Multiple Robot System," Master's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREA: Surface/Under Surface Vehicles – Ships and Watercraft

KEYWORDS: Wireless Communications, Damage Control

CHAOTIC SYNCHRONIZATION FOR SECURE COMMUNICATION

Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To investigate the feasibility of secure communications utilizing synchronization of chaotic dynamic systems.

SUMMARY: Application of chaotic synchronization to secure communications was investigated. A system prototype was built for the purpose of validating the concept. The prototype consists of two major subsystems: a chaotic generator and a chaotic synchronizer. The chaotic generator implemented a third-order Lorenz system using analog RC components. An analog voice signal was mixed with chaotic signal and transmitted. The voice signal was recovered at the synchronizer end. The experiment demonstrated that the concept of chaotic synchronization for secure communication was feasible.

OTHER:

A prototype of the chaotic system was built and is available for proper certification of chaotic synchronization as an alternative means for secure communications.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Command, Control and Communication, Electronic Warfare, Electronics

KEYWORDS: Secure Communications, Chaotic Synchronization, Chaotic Dynamic Systems, Lorenz System

AN INTEGRATED INS/GPS SHALLOW-WATER AUTONOMOUS UNDERWATER VEHICLE NAVIGATION SYSTEM

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: The objective of this project is to develop an integrated self-contained shallow-water navigation system for autonomous underwater vehicles (AUV).

SUMMARY: A Small AUV Navigation System (SANS) is being developed at the Naval Postgraduate School. The SANS is an integrated GPS/INS navigation system composed of low-cost and small-size components. It is designed to demonstrate the feasibility of using a low-cost strapped-down inertial measurement unit (IMU) to navigate between GPS fixes. The present hardware consists of a GPS/DGPS receiver, IMU, compass, water speed sensor, water depth sensor, and a data processing computer. The software is based on a twelve-state complementary Kalman filter. This paper describes hardware and software design, and testing results of the SANS. It is shown that results from tilt table testing and bench testing provide an effective means for tuning filter gains. Results from ground vehicle testing demonstrate that the SANS is able to navigate 10 meter accuracy for more than three minutes between DGPS fixes.

PUBLICATION:

Yun, X., Bachmann, E.R., McGhee, R.B., Whalen, R.H., Roberts, R.L., Knapp, R.G., Healey, A.J., and Zyda, M.J., "Testing and Evaluation of an Integrated GPS/INS System for Small AUV Navigation (SANS)," *Proceedings of the 10th International Symposium on Unmanned Untethered Submersible Technology (UUST)*, Durham, NH, 7-10 September 1997.

THESES DIRECTED:

Knapp, R.G., "Calibration and Evaluation of Water Speed Indicator and Compass for the Small Autonomous Underwater Vehicle Navigation Filter," Master's Thesis, Naval Postgraduate School, September 1997.

Young, F., "Distributed Control and Sensing of Autonomous Underwater Vehicles Using LonTalk," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Surface/Under Surface Vehicles – Ships and Watercraft

KEYWORDS: IMU, GPS, Navigation, Autonomous Underwater Vehicle

RESEARCH ON A SEMI-AUTONOMOUS GROUND AND AERIAL VEHICLE SYSTEM FOR MINE/UNEXPLODED ORDNANCE (UXO) DETECTION AND CLEARING

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVE: To investigate and develop a semi-autonomous robot system for land mine/UXO searching/processing tasks in humanitarian operations.

PROJECT SUMMARIES

SUMMARY: This is a multi-disciplinary project involving faculty and students from four NPS departments. The overall goal was to develop a semi-autonomous robotic system for searching land mines and UXOs. A four-wheel-drive and four-wheel-steering vehicle for mine/UXO searching in rough terrains was designed and built. The PI's contribution to the project was in the area of control and navigation of the vehicle. Low-level servo control of the vehicle is implemented and tested. An integrated INS/GPS navigation system was installed. A navigation algorithm that combines readings from shaft encoders, GPS, and inertial sensors is developed and implemented.

PUBLICATION:

Kanayama, Y.J. and Yun, X., "Rigid Body Motion Analysis towards Rotary Vehicle," *ICRA '97 Workshop on Innovative Designs of Wheeled Mobile Robots*, Albuquerque, NM, 20 April 1997.

THESIS DIRECTED:

Leonardy, T., "Implementation and Evaluation of an INS Navigation System for the Shepherd Mobile Robot," Master's Thesis, Naval Postgraduate School, December 1997.

DoD KEY TECHNOLOGY AREAS: Ground Vehicles, Other (Robotic Technology)

KEYWORDS: Land Mines, Unexploded Ordnance (UXO), Mobile Robots, Navigation

SUPPORT OF THE NEAR SHORE TACTICAL RECONNAISSANCE (NSTR) PROGRAM

Lawrence J. Ziomek, Professor

Department of Electrical and Computer Engineering

Sponsors: Defense Advanced Research Projects Agency and Naval Postgraduate School

OBJECTIVE: Deliver the recursive ray acoustics (RRA) computer algorithm to the Applied Physics Laboratory-Johns Hopkins University (APL-JHU) in support of the Near Shore Tactical Reconnaissance (NSTR) Program. Be available for consultation to APL-JHU to ensure the successful running, testing, and evaluation of the RRA algorithm. Time permitting, further investigate the use of two-dimensional orthogonal function expansions of noise corrupted and/or uncertain environmental data and incorporate into the existing shallow water pulse-propagation model, which is based on the RRA algorithm. Specifically, fit surfaces to two-dimensional ocean-bottom depth data, that is, bathymetry as a function of cross-range and down-range. Such ocean bottom surface fits allow for the prediction of out-of-plane ray propagation due to bottom bounces which can impact bearing estimation algorithms used for target localization. In addition, fit surfaces to two-dimensional speed-of-sound data, that is, sound speed as a function of depth and down-range.

SUMMARY: The recursive ray acoustics (RRA) computer algorithm was delivered to the Applied Physics Laboratory-Johns Hopkins University (APL-JHU) in support of the Near Shore Tactical Reconnaissance (NSTR) Program. The RRA algorithm was run at both NPS and APL-JHU for several identical test cases. The results obtained from running the program at both institutions were exactly the same. Further evaluation and testing of the RRA algorithm at the APL-JHU revealed that higher-order one-dimensional orthogonal function expansions of depth-dependent sound-speed data are required in order to successfully fit complicated sound-speed profiles. As a result, the maximum order fit was increased from 5th-order to 13th-order for both sound-speed and bathymetric data. In addition, Chebyshev polynomials are now used in the Gram-Schmidt procedure to generate the orthogonal polynomials with improved numerical accuracy. The use of the modified Gram-Schmidt orthogonalization technique was also investigated. It did not perform significantly better than simply using Chebyshev polynomials in the Gram-Schmidt procedure to generate the orthogonal polynomials. Finally, automatic 90 degree phase corrections are now made to the phase along a ray path each time a ray path passes through a focal point.

PROJECT SUMMARIES

OTHER:

Ziomek, L.J., "The Recursive Ray Acoustics (RRA) Algorithm," SRI International, Menlo Park, CA, 31 January 1997.

Ziomek, L.J., "Underwater Acoustic Pulse Propagation Using the Recursive Ray Acoustics (RRA) Algorithm," invited speaker at the ONR USW Broadband Processing Working Group, Naval Postgraduate School, Monterey, CA, 10-11 December 1997.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Recursive Ray Acoustics (RRA) Algorithm, Orthogonal Function Expansions of Environmental Data, Pulse (Transient) Propagation Modeling, Shallow Water Acoustics, Target Localization

MATHEMATICAL MODELING OF DOLPHIN BIOSONAR

Lawrence J. Ziomek, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: Two major objectives: (1) Derive an accurate and realistic mathematical model for a typical, individual, broadband click pulse that is transmitted by the Atlantic Bottlenose Dolphin (*Tursiops Truncatus*). One way to get a definitive answer as to what kind of amplitude modulation and angle modulation (if any) is present, is to perform a quadrature decomposition on experimental data of individual click pulses transmitted by *Tursiops Truncatus*. A computer program will be written that will perform a quadrature decomposition on the data. (2) Derive accurate and realistic mathematical models of the receive aperture and the corresponding receive, far-field beam pattern of *Tursiops Truncatus*. After the mathematical modeling is done, a computer program will be written to simulate both the receive aperture and the receive, far-field beam pattern. If any experimental data of the frequency response of the receive aperture of a *Tursiops Truncatus* is available, it can be incorporated into the models. Experimental data will be provided by the Tropical Marine Science Initiative (TMSI) of the National University of Singapore.

SUMMARY: Work began on the development of a computer program that will perform a quadrature decomposition on experimental data of individual click pulses transmitted by the Atlantic Bottlenose Dolphin (*Tursiops Truncatus*).

DoD KEY TECHNOLOGY AREAS: Biomedical, Modeling and Simulation

KEYWORDS: Dolphin, Biosonar, Dolphin Biosonar

PROJECT SUMMARIES
